Long Lake

Oneida County, Wisconsin

Comprehensive Management Plan

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Long Lake Planning Committee

Jack Werner
Tom Thayer
Scott Eppler
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Fred Knoch
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Tom Harris
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1.0 INTRODUCTION

Long Lake, Oneida County, is a 620-acre drainage lake with a maximum depth of 31 and a shoreline that is just less than 7.5 miles long (Map 1). This eutrophic lake has a very (>70,000 acres) large watershed when compared to the size of the lake. Long Lake and the connecting Eagle River Channel contain 55 native plant species, of which common waterweed is the most common plant. A single submersed exotic plant, Eurasian water milfoil, is known to exist in Long Lake. Several occurrences of hybrid cattail and sweetflag, two emergent exotic plant species, were noted along the shorelines of Long Lake.

Field Survey Notes

Eurasian water milfoil seems to be isolated to Eagle River channel. Myriophyllum verticillatum (commonly mistaken for Eurasian water milfoil) *and other native dicot species found outside of 2009 treatment areas. Slightly stained water. Much of lake has very natural shoreline – good wildlife habitat.*

Photograph 1.0-1 Long Lake, Oneida County

Lake at a Glance - Long Lake

Morphology	
Acreage	620
Maximum Depth (ft)	31
Mean Depth (ft)	13
Shoreline Complexity	4.6
Vegetation	
Curly-leaf Survey Date	June 11, 2009
Comprehensive Survey Date	July 3, 2009
Number of Native Species	44 (Long Lake) 37 (Eagle River Channel); 55 total
Threatened/Special Concern Species	Vasey's pondweed
Exotic Plant Species	Eurasian water milfoil, sweetflag, hybrid cattail
Simpson's Diversity	0.90
Average Conservatism	6.7
Water Quality	
Trophic State	Lower eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	7.5
Sensitivity to Acid Rain	Not sensitive
Watershed to Lake Area Ratio	115:1

Long Lake, Oneida County, lies downstream of the over 6,100-acre Three Lakes Chain. The Eagle River flows from Long Lake over the Burnt Rollways Dam into Cranberry Lake, part of the Lower Eagle River Chain of Lakes. The Burnt Rollways Dam was constructed in 1907 to retain water for water conservation, flood control, regulation of uniform flow of the Wisconsin River and hydroelectric purposes and dams along the river. The dam was built and is currently owned and operated by the Wisconsin Valley Improvement Company (WVIC). The dam operates under a range of 2.75 feet (maximum of 1,625.71 ft NGVD to a minimum of 1622.96 ft NGVD). The WVIC website (www.wvic.com) reports that this dam retains a gross storage of 4,525 million cubic feet (mcf). In 1911, the WVIC built a boat hoist at the dam. This early hoist was powered by the stream of water the dam produced to lift boats up an inclined railway. In 1952, the hoist was upgraded to an electric gantry hoist that is capable of transporting boats of all sizes from one side of the dam to the other more quickly.

In addition to the 14 public boat landings on the chain, there is access to the eight boat landings on the Lower Eagle River Chain by traveling over the Burnt Rollways Dam using the tracked boat-lift system. The system contains numerous resorts, many which contain their own private boat landing. In addition, numerous fishing tournaments are held on the system each year. It is likely because of the high use of this system that Eurasian water milfoil became well established within the Lower Eagle River Chain. During the summer of 2006, a pioneer infestation of Eurasian water milfoil was located approximately 0.25 mi. upstream from the Burnt Rollways Dam (Map 1). As a result of that finding, the Wisconsin Department of Natural Resources (WDNR) issued an Aquatic Invasive Species (AIS) Early Detection and Rapid Response Grant to the Town of Three Lakes.

Besides a pioneer infestation upstream of the Burnt Rollways Dam and a small Eurasian water milfoil infestation discovered during 2010 surveys on Virgin Lake (at the top of the flowage system), no other lakes in the Three Lakes Chain are known to contain this exotic species. The Three Lakes Waterfront Association (TLWA) recognizes the impact this invasive plant has had on other waterbodies, and in February 2009 successfully applied for a Lake Management Planning Grant through the WDNR to conduct studies upon the lake.

The TLWA chose to complete the planning program for three main reasons: 1) to learn the extent of the exotic plants which occur in their lake, 2) to understand their lake ecosystem more fully, and 3) to be eligible to receive additional WDNR grant funds to address AIS and other goals of lake stakeholders. The data collected from this lake management project will serve as a baseline set of data for which future management planning projects can call upon. Therefore, this project is important not only in the management and protection of the lake, but also in its likely restoration. Specifically, this management plan outlines the specific steps necessary to restore important native habitat within and around Long Lake.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa. The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All of this information is communicated through multiple meetings that involve the lake group as a whole or a focus group called a Planning Committee, the completion of a stakeholder survey, and updates within the lake group's newsletter.

The highlights of this component are described below in chronological order. Materials used during the planning process can be found in Appendix A.

Kick-off Meeting
On July 11th, 2009, a project kick-off presentation was delivered during the TLWA annual meeting to introduce the project to the general public. The meeting was announced through a mailing and personal contact by TLWA board members. The presentation was given by Tim Hoyman, an aquatic ecologist with Onterra. Mr. Hoyman's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation was followed by a question and answer session.

Stakeholder Survey
During the summer of 2010, Onterra staff and the Long Lake Planning Committee developed an eight page, 33-question survey. This survey was submitted to a WDNR sociologist for review, and was approved in August of 2010. That same month, the survey was mailed to 169 riparian property owners in the Long Lake watershed. 45.6 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Long Lake Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan.

Planning Committee Meeting I
On September 2, 2010, Tim Hoyman of Onterra met with eight members of the Long Lake Planning Committee for nearly 3 hours. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including, Eurasian water milfoil treatment results, aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed. Many concerns were raised by the committee, including, water conditions, beaver dam management, and the proposed expansion of the state-owned campground.

Planning Committee Meeting II

On October 13, 2010, Tim Hoyman met with the members of the Planning Committee to discuss the stakeholder survey results and begin developing management goals and actions for the Long Lake management plan.

Management Plan Review and Adoption Process

The Long Lake Planning Committee met in June of 2011 to discuss the outcome of the Planning Meetings and the first draft of the Long Lake Comprehensive Management Plan. A list of proposed changes regarding the content of the document was received by Onterra later that month and addressed. A second draft was sent to the Planning Committee, as well as Kevin Gauthier of the WDNR, in early October of 2011 for further review. Kevin Gauthier and John Kubisiak (WDNR fisheries biologist) provided feedback in October of 2012. Their comments were addressed, and a final management plan produced in December of 2012. Once the plan was finalized, the 15 members of the TLWA Board of Directors officially accepted the plan, and began implementation of activities revealed during the planning process.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, not all chemical attributes collected may have a direct bearing on the lake's ecology, but may be more useful as indicators of other problems. Finally, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

Many types of analysis are available for assessing the condition of a particular lake's water quality. In this document, the water quality analysis focuses upon attributes that are directly related to the ecology of the lake. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. Specific forms of water quality analysis are used to indicate not only the health of the lake, but also to provide a general understanding of the lake's ecology and assist in management decisions. Each type of available analysis is elaborated on below.

Comparisons with Other Datasets

As mentioned above, chemistry is a large part of water quality analysis. In most cases, listing the values of specific parameters really does not lead to an understanding of a lake's water quality, especially in the minds of non-professionals. A better way of relating the information is to compare it to similar lakes in the area. In this document, a portion of the water quality information collected in Long Lake are compared to other lakes in the region and state (Appendix C). In addition, the assessment can also be clarified by limiting the primary analysis to parameters that are important in the lake's ecology and trophic state (see below). Three water quality parameters are focused upon in the Long Lake water quality analysis:

> **Phosphorus** is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both *algae* and *macrophytes*. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.
>
> **Chlorophyll-*a*** is the green pigment in plants used during *photosynthesis*. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.
>
> **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by

lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are interrelated. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water (Canter et al. 1994, Dinius 2007, and Smith et al. 1991).

Lillie and Mason (1983) is an excellent source of data for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Oneida County lakes are included within the study's Northeast Region (Figure 3.1-1) and are among 242 lakes randomly sampled from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means and historic data from Long Lake are displayed in Figures 3.1-2 – 3.1-4. Please note that the data in these graphs represent values collected only during the summer months (June-August) from the deepest location in Long Lake (Map 1). Furthermore, the phosphorus and chlorophyll-a data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments (see discussion under Internal Nutrient Loading on page 9). Surface samples in Long Lake were collected at a depth of 3 feet.

Figure 3.1-1. Location of Long Lake within the regions utilized by Lillie and Mason (1983).

Apparent Water Quality Index

Water quality, like beauty, is often in the eye of the beholder. A person from southern Wisconsin that has never seen a northern lake may consider the water quality of their lake to be good if the bottom is visible in 4 feet of water. On the other hand, a person accustomed to seeing the bottom in 18 feet of water may be alarmed at the clarity found in the southern lake.

Lillie and Mason (1983) used the extensive data they compiled to create the *Apparent Water Quality Index* (WQI). They divided the phosphorus, chlorophyll-*a*, and clarity data of the state's lakes into ranked categories and assigned each a "quality" label from "Excellent" to "Very Poor". The categories were created based upon natural divisions in the dataset and upon their experience. As a result, using the WQI as an assessment tool is very much like comparing a particular lake's values to values from many other lakes in the state. However, the use of terms like, "Poor", "Fair", and "Good" bring about a better understanding of the results than just comparing averages or other statistical values between lakes. The WQI values corresponding to the phosphorus, chlorophyll-*a*, and Secchi disk values for Long Lake are displayed on Figures 3.1-2 – 3.1-4.

Trophic State

Total phosphorus, chlorophyll-*a*, and water clarity values are directly related to the *trophic state* of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: *oligotrophic*, *mesotrophic*, and finally *eutrophic*. Every lake will naturally progress through these states and under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in many Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production. However, through the use of a *trophic state index* (TSI), an index number can be calculated using phosphorus, chlorophyll-*a*, and clarity values that represent the lake's position within the eutrophication process. This allows for a more clear understanding of the lake's trophic state while facilitating clearer long-term tracking.

Trophic states describe the lake's ability to produce plant matter (production) and include three continuous classifications: *Oligotrophic* lakes are the least productive lakes and are characterized by being deep, having cold water, and few plants. *Eutrophic* lakes are the most productive and normally have shallow depths, warm water, and high plant biomass. *Mesotrophic* lakes fall between these two categories.

Carlson (1977) presented a trophic state index that gained great acceptance among lake managers. Because Carlson developed his TSI equations on the basis of association among water clarity, chlorophyll-*a*, and total phosphorus values of a relatively small set of Minnesota Lakes, researchers from Wisconsin (Lillie et. al. 1993), developed a new set of relationships and equations based upon the data compiled in Lillie & Mason (1983). This resulted in the Wisconsin Trophic State Index (WTSI), which is essentially a TSI calibrated for Wisconsin lakes. The WTSI is used extensively by the WDNR and is reported along with lake data collected by Citizen Lake Monitoring Network volunteers.

Limiting Nutrient

The *limiting nutrient* is the nutrient which is in shortest supply and controls the growth rate of algae and some macrophytes within the lake. This is analogous to baking a cake that requires four eggs, and four cups each of water, flour, and sugar. If the baker would like to make four cakes, he needs 16 of each ingredient. If he is short two eggs, he will only be able to make three cakes even if he has sufficient amounts of the other ingredients. In this scenario, the eggs are the limiting nutrient (ingredient).

In most Wisconsin lakes, phosphorus is the limiting nutrient controlling the production of plant biomass. As a result, phosphorus is often the target for management actions aimed at controlling plants, especially algae. The limiting nutrient is determined by calculating the nitrogen to phosphorus ratio within the lake. Normally, total nitrogen and total phosphorus values from the surface samples taken during the summer months are used to determine the ratio. Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 15:1, the lake is considered phosphorus limited; if it is less than 10:1, it is considered nitrogen limited. Values between these ratios indicate a transitional limitation between nitrogen and phosphorus.

Temperature and Dissolved Oxygen Profiles

Temperature and dissolved oxygen profiles are created simply by taking readings at different water depths within a lake. Although it is a simple procedure, the completion of several profiles over the course of a year or more provides a great deal of information about the lake. Much of this information relates to whether the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fishkills are often the result of insufficient amounts of dissolved oxygen. However, dissolved oxygen's role in lake management extends beyond this basic need by living organisms. In fact, its presence or absence impacts many chemical process that occur within a lake. Internal nutrient loading is an excellent example that is described below.

Lake stratification occurs when temperature gradients are developed with depth in a lake. During stratification the lake can be broken into three layers: The *epiliminion* is the top layer of water which is the warmest water in the summer months and the coolest water in the winter months. The *hypolimnion* is the bottom layer and contains the coolest water in the summer months and the warmest water in the winter months. The *metalimnion*, often called the thermocline, is the middle layer containing the steepest temperature gradient.

Internal Nutrient Loading*In lakes that support strong stratification, the hypolimnion can become devoid of oxygen both in the water column and within the sediment. When this occurs, iron changes from a form that normally binds phosphorus within the sediment to a form that releases it to the overlaying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algae blooms decades after external sources are controlled.

The first step in the analysis is determining if the lake is a candidate for significant internal phosphorus loading. Water quality data and watershed modeling are used to screen non-candidate and candidate lakes following the general guidelines below:

Non-Candidate Lakes

- Lakes that do not experience hypolimnetic anoxia.
- Lakes that do not stratify for significant periods (i.e. months at a time).
- Lakes with hypolimnetic total phosphorus values less than 200 μg/L.

Candidate Lakes

- Lakes with hypolimnetic total phosphorus concentrations exceeding 200 µg/L.
- Lakes with epilimnetic phosphorus concentrations that cannot be accounted for in watershed phosphorus load modeling.

Specific to the final bullet-point, during the watershed modeling assessment, the results of the modeled phosphorus loads are used to estimate in-lake phosphorus concentrations. If these estimates are much lower than those actually found in the lake, another source of phosphorus must be responsible for elevating the in-lake concentrations. Normally, two possibilities exist; 1) shoreland septic systems, and 2) internal phosphorus cycling.

If the lake is considered a candidate for internal loading, modeling procedures are used to estimate that load.

*Lack of hypolimnetic phosphorus data prevents these analyses from being performed. The explanation provided under this heading is strictly for the information of the reader.

Long Lake Water Quality Analysis

Long Lake Long-term Trends

As described above, the long-term trend analysis focuses upon three parameters, total phosphorus, chlorophyll-*a*, and Secchi disk clarity. For Long Lake, very little historic phosphorus and chlorophyll-*a* data exists in the WDNR and Environmental Protection Agency databases. However, there is a substantial collection of Secchi disk clarity measurements that have been collected over the past two decades. While some general conclusions may be made regarding the quality of the water in Long Lake, it is irresponsible to attempt a long term trend analysis with irregular data for all three parameters, as environmental conditions can often influence one or all of these variables on an annual basis.

Total phosphorus data for Long Lake was collected during 1979, again between 2000 and 2002, and then not until 2009 (Figure 3.1-2). While the graph depicts somewhat of a downward trend, remember that there are gaps in time amongst the values in which environmental conditions (rain, temperature, etc) might influence the concentration of phosphorus in the water column from year to year. Therefore, this conclusion cannot be made due to the lack of data. However, it is apparent that the limited data available does remain within the “Good” range of the WQI and that the summer values are very comparable to those from the similar lakes around the state of Wisconsin and in the Northeast region.

Similar to the phosphorus data, the chlorophyll-*a* dataset for Long Lake is limited and not without large gaps in time. With the exception of a 1979 measurement, chlorophyll-*a* concentrations in Long Lake have remained in the WQI “Fair” category and a weighted average over all available years of data is below the average for similar lakes statewide and regionally.

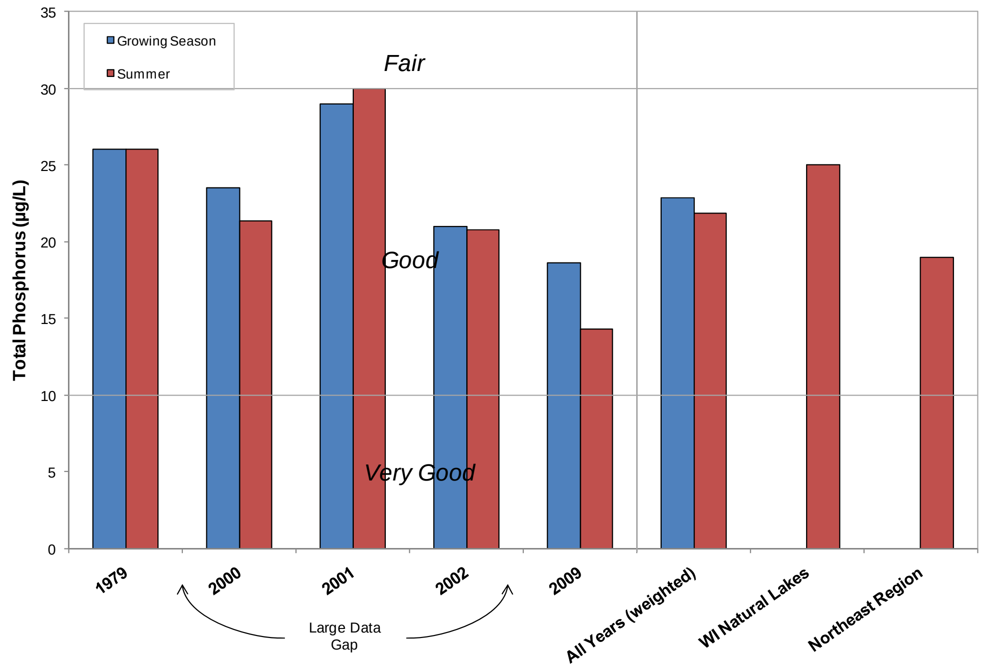

Figure 3.1-2. Long Lake, regional, and state total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

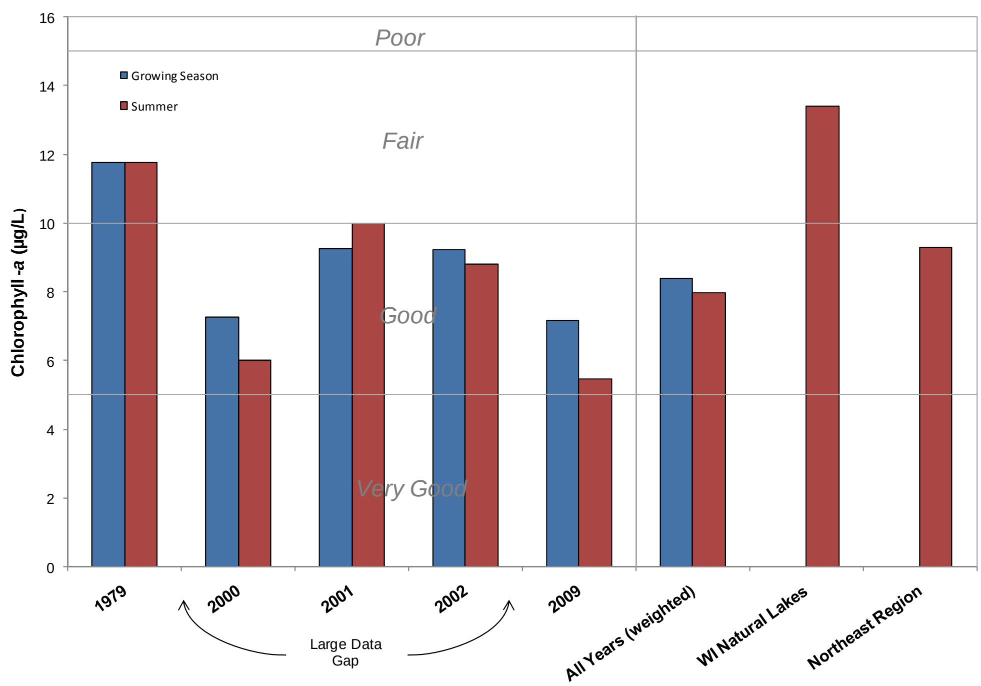

Figure 3.1-3. Long Lake, regional, and state chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Of the three primary water quality parameters analyzed in this project, Secchi disk clarity has been measured the most on Long Lake, and with the most consistency. The majority of these measurements fall between roughly 6.5 to 8 feet of depth, which is "Good" according to the WQI. Furthermore, a weighted average of the dataset is only slightly lower than averages for similar lakes around the state and within the Northeast Region.

At first glance, it may appear that there is a slight downward (increasing depth) trend within the Secchi disk clarity dataset. However it is important to note several factors which may influence bias on this judgment. First, it is likely that these parameters are influenced heavily by variations in climatic conditions. Particularly, precipitation has a large impact on lake nutrient content (which in turn influences algae and water clarity). State climatologists agree that the north region of Wisconsin is currently experiencing drought conditions, which have persisted over the past 8 years. While these conditions have existed over the long-term (8 years), annual variations in precipitation have still occurred. For example, in summer of 2004 this region of Wisconsin received approximately 3 less inches of precipitation than that of the past 100 year average. However only two years prior, in 2002, this region received nearly 2.5 more inches than the past 100 year average. While this may seem like an insignificant amount, remember a lake with a very large watershed is able to catch a large amount of precipitation. In 2002 when there was a larger than average amount of precipitation, Secchi disk clarity averaged 7.25 feet. In 2004, this annual average was 9.5 feet. With more precipitation, a lake should receive more runoff (both nutrients and sediments) which will reduce water clarity. The opposite is true during periods of less precipitation. In conclusion, what may appear as a trend in Secchi disk clarity is actually the result of dynamic weather variations in northern Wisconsin.

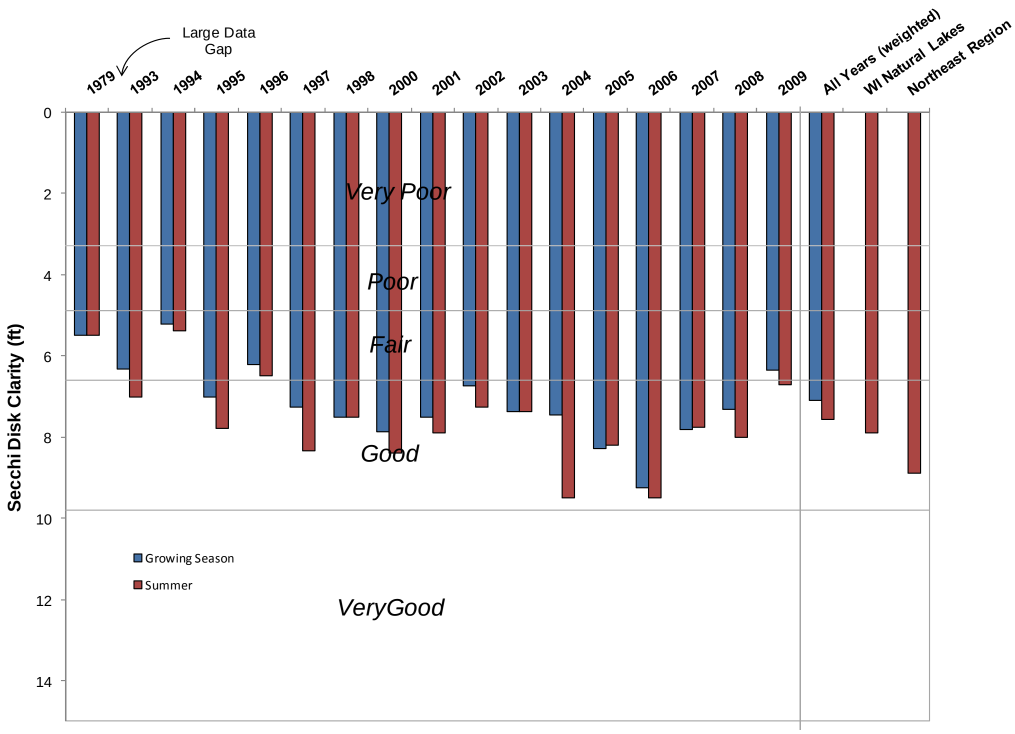

Figure 3.1-4. Long Lake, regional, and state Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Limiting Plant Nutrient of Long Lake

Using midsummer nitrogen and phosphorus concentrations from Long Lake, a nitrogen:phosphorus ratio of 32:1 was calculated. This finding indicates that Long Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Long Lake Trophic State

Figure 3.1-5 contain the WTSI values for Long Lake. The WTSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from lower eutrophic to middle mesotrophic. In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* WTSI values, it can be concluded that Long Lake is in a lower eutrophic state.

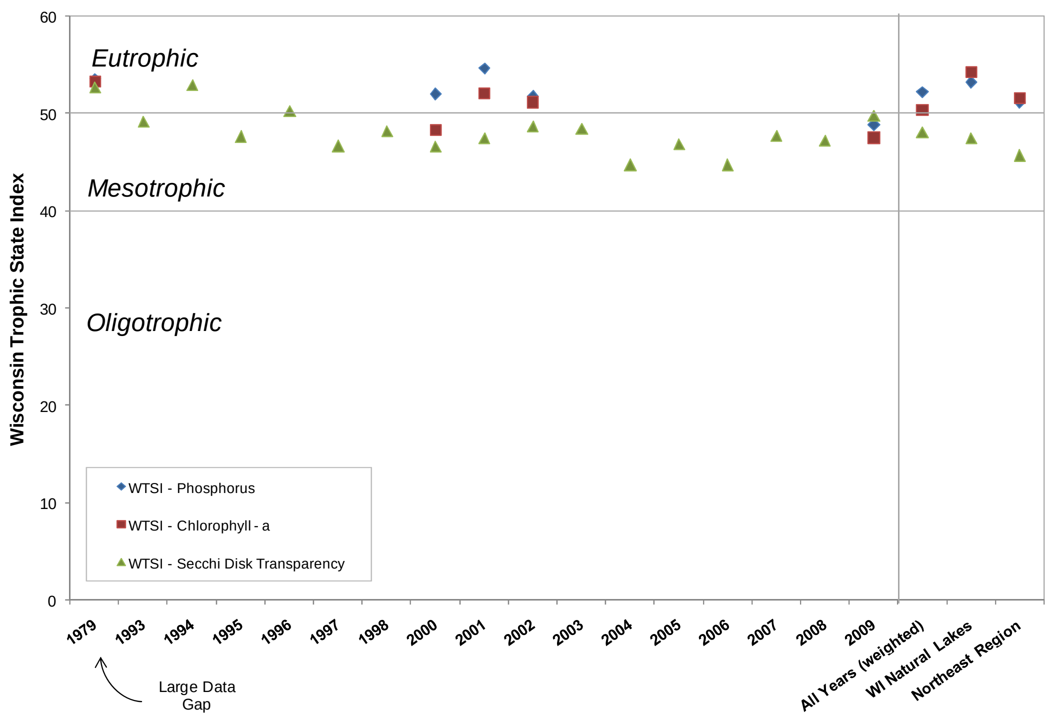

Figure 3.1-5. Long Lake, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993).

Dissolved Oxygen and Temperature in Long Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Long Lake by Onterra staff. Graphs of those data are displayed in Figure 3.1-6.

Long Lake was found to stratify in June, however became somewhat mixed later in the summer and fully mixed in the fall. This is not uncommon in lakes that are moderate in both size and depth. Energy from the wind is sufficient to mix the lake from top to bottom, distributing oxygen throughout the epilimnion and hypolimnion and keeping water temperatures fairly constant within the water column. On a lake such as Long, with a considerable depth, it takes a large amount of energy to do this. Decomposition of organic matter along the lake bottom is the cause of the decrease in dissolved oxygen observed in the summer and winter months. Despite the decrease in dissolved oxygen levels along the bottom of the lake, the majority of the water column held concentrations high enough (>3.0 mg/L) to support most aquatic life found in northern Wisconsin lakes.

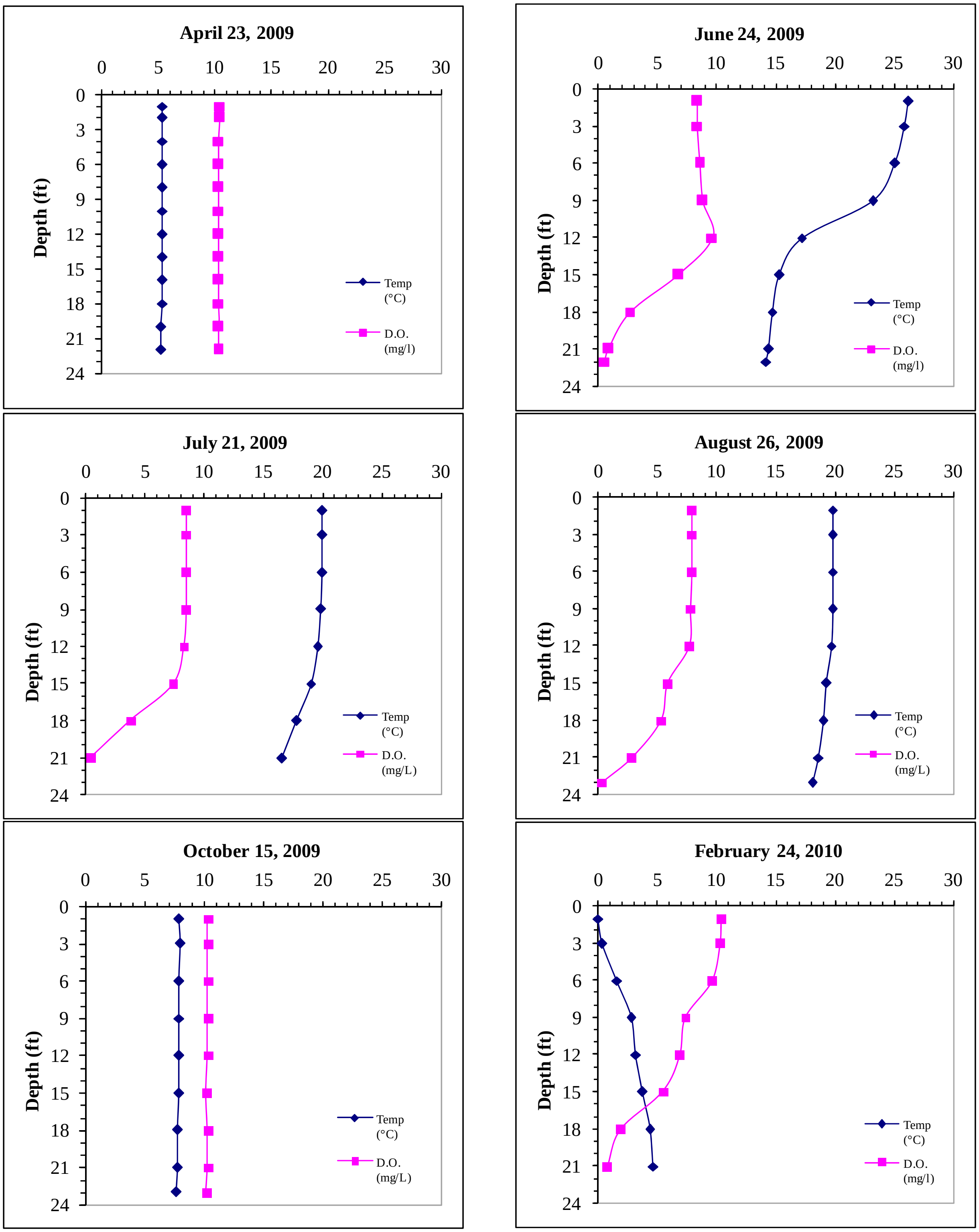

Figure 3.1-6. Long Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Long Lake

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Long Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw et al. 2004). The pH of the water in Long Lake was found to be near neutral with a value of 7.5, and falls within the normal range for Wisconsin Lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Long Lake ranged between 26.4 and 32.6 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Long Lake's pH of 7.5 falls within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Long Lake was found to be 7.5 mg/L, falling well below the optimal range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2009 and these samples were processed by the WDNR for larval zebra mussels. The samples did not turn up any occurrences of the larval zebra mussels, so it is not suspected that this AIS inhabits Long Lake.

3.2 Watershed Assessment

A lake's **flushing rate** is simply a determination of the time required for the lake's water volume to be completely exchanged. **Residence time** describes how long a volume of water remains in the lake and is expressed in days, months, or years. The parameters are related and both determined by the volume of the lake and the amount of water entering the lake from its watershed. Greater flushing rates equal shorter residence times.

Two aspects of a lake's watershed are the key factors in determining the amount of phosphorus the watershed exports to the lake; 1) the size of the watershed, and 2) the land cover (land use) within the watershed. The impact of the watershed size is dependent on how large it is relative to the size of the lake. The watershed to lake area ratio (WS:LA) defines how many acres of watershed drains to each surface-acre of the lake. Larger ratios result in the watershed having a greater role in the lake's annual water budget and phosphorus load.

The type of land cover that exists in the watershed determines the amount of phosphorus (and sediment) that runs off the land and eventually makes its way to the lake. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to permeate the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas, minimize infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased phosphorus and pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations.

In systems with lower WS:LA ratios, land cover type plays a very important role in how much phosphorus is loaded to the lake from the watershed. In these systems the occurrence of agriculture or urban development in even a small percentage of the watershed (less than 10%) can unnaturally elevate phosphorus inputs to the lake. If these land cover types are converted to a cover that does not export as much phosphorus, such as converting row crop areas to grass or forested areas, the phosphorus load and its impacts to the lake may be decreased. In fact, if the phosphorus load is reduced greatly, changes in lake water quality may be noticeable, (e.g. reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

In systems with high WS:LA ratios, like those exceeding 10-15:1, the impact of land cover may be tempered by the sheer amount of land draining to the lake. Situations actually occur where lakes with completely forested watersheds have sufficient phosphorus loads to support high rates of plant production. In other systems with high ratios, the conversion of vast areas of row crops to vegetated areas (grasslands, meadows, forests, etc.) may not reduce phosphorus loads sufficiently to see a change in plant production. Both of these situations occur frequently in impoundments.

Regardless of the size of the watershed or the makeup of its land cover, it must be remembered that every lake is different and other factors, such as flushing rate, lake volume, sediment type, and many others, also influence how the lake will react to what is flowing into it. For instance, a deeper lake with a greater volume can dilute more phosphorus within its waters than a less voluminous lake and as a result, the production of a lake is kept low. However, in that same lake, because of its low flushing rate (high residence time, i.e., years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time that internal nutrient loading may become a problem. On the contrary, a lake with a higher flushing rate (low residence time, i.e., days or weeks) may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

A reliable and cost-efficient method of creating a general picture of a watershed's affect on a lake can be obtained through modeling. The WDNR created a useful suite of modeling tools called the Wisconsin Lake Modeling Suite (WiLMS). Certain morphological attributes of a lake and its watershed can be entered into WiLMS along with the acreages of different types of land cover within the watershed to produce useful information about the lake ecosystem. This information includes an estimate of annual phosphorus load and the partitioning of those loads between the watershed's different land cover types and atmospheric fallout entering through the lake's water surface. WiLMS also calculates the lake's flushing rate and residence times using county-specific average precipitation/evaporation values or values entered by the user. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

Long Lake's immediate watershed is approximately 2,406 acres in size, however because Long Lake is downstream of a particularly large chain of lakes, its contributing watershed basin is actually much larger (Map 2). In fact, the Long Lake watershed is about 71,559 acres in size. 69,153 acres, or 97% of the total watershed is found in the upstream chain of lakes. The remaining 3% can be found in Long Lakes immediate watershed, which contains 1,351 acres of forest (56% of the original 3%), 620 acres of the lake surface (26%), 378 acres of wetland (16%), and smaller portions of pasture/grass and row crop agriculture (Figure 3.1-1 and 3.1-2). The watershed to lake area ratio is 115:1, which, as discussed earlier, indicates that the land cover types plays a minor role in the water quality of Long Lake. The acreage of land contributing nutrients and water to Long Lake is so immense that differences in land cover types are rather inconsequential.

WiLMS modeling utilizing the land cover types and acreages found in Figure 3.2-1 results in an estimated annual phosphorus load of 4,307 lbs for Long Lake (Figure 3.2-3 and Appendix D). This is a reasonable amount considering the size of the contributing watershed. The upstream lakes and their individual watersheds are responsible for 92% of this annual load. The remaining 8% is split between land cover types in the immediate watershed and include the Long Lake surface (4%), forested land (3%), wetland (1%) and very small portions from pasture/grass and row crop agriculture.

Although Long Lake receives an incredible amount of phosphorus on an annual basis, it is likely able to withstand larger phosphorus inputs because of its size and its hydrology. Long Lake is characterized as being a drainage lake because of its input tributary (from Planting Ground Lake) and its output tributary (the Eagle River Channel). As opposed to a seepage lake, which has no inlets or outlets, a drainage lake will recycle its water (or "flush" itself) at a quicker rate. With a greater quantity of water entering a lake (from a larger watershed), this process (termed the *lake* *flushing rate*) will occur more often than in seepage lakes or lakes with a smaller watershed. WiLMS estimates that Long Lake flushes its total water volume 9.2 times in a year. This process occurs about every 40 days, and helps to remove nutrients or pollutants which would otherwise accumulate in the system. Without this high flushing rate, it is very likely that the lake's water and overall ecosystem would be of lesser quality.

As previously mentioned, the Long Lake watershed is quite large when compared to the size of the actual lake. Because of the size of the contributing basin, conservation efforts taking place in the greater watershed will probably have little influence on enhancing the ecosystem of Long Lake. In all actuality, there is very likely little opportunity for land use changes in this watershed anyways. Like most northern Wisconsin lakes, the upstream chain of lakes is surrounded by large tracts of forested land as well as wetlands, which are protected. These land cover types are ideal for reducing nutrient and sediment inputs into lakes. If even small amounts of forests and wetlands within the Long Lake watershed were to be developed into agricultural or urban lands, the phosphorus load would increase substantially, and impacts would likely be noticeable.

If restoration or protection efforts are to take place in the watershed, the area of top priority would be the lakes immediate shoreline. When a lake's shoreline is developed, the increased impervious surface, removal of natural vegetation, installation of septic systems, and other human practices can severely increase nutrient loads to the lake while degrading important habitat. Placing property in a conservation easement, or land trust, ensures that these sensitive areas are protected for years to come. These options are discussed further within the Implementation Plan. Limiting these anthropogenic (human derived) affects on the lake is important in maintaining the quality of the lake's water and habitat.

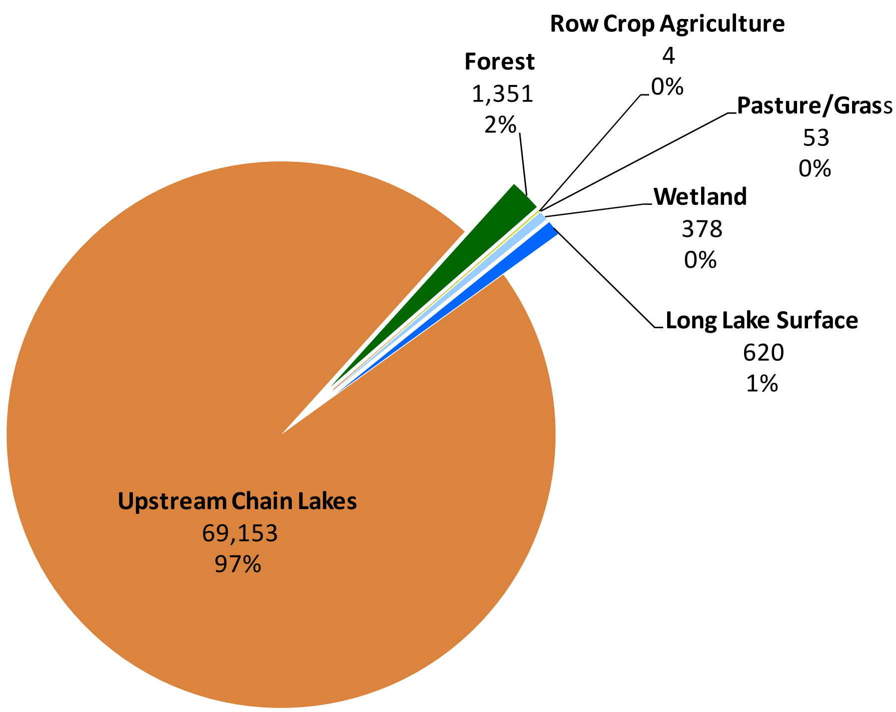

Figure 3.2-1. Long Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

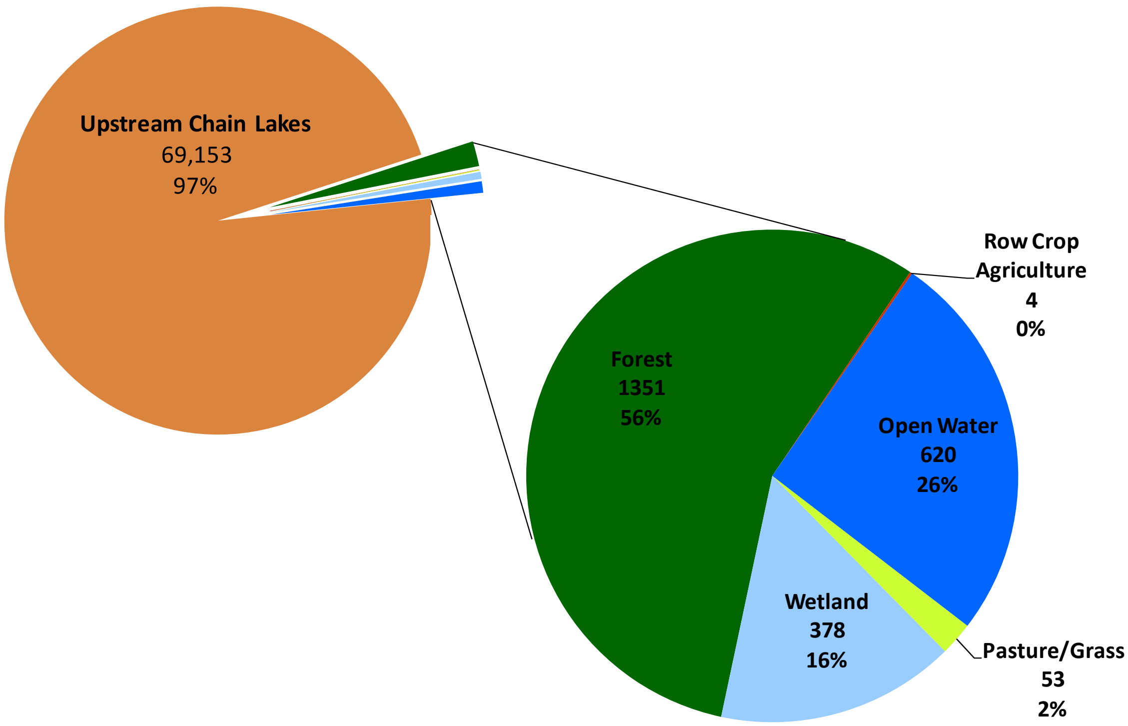

Figure 3.2-2. Immediate Long Lake watershed land cover types in acres. Graph represents immediate acreage not found within upstream lakes' watersheds, and represents approximately 3% of the total Long Lake watershed. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

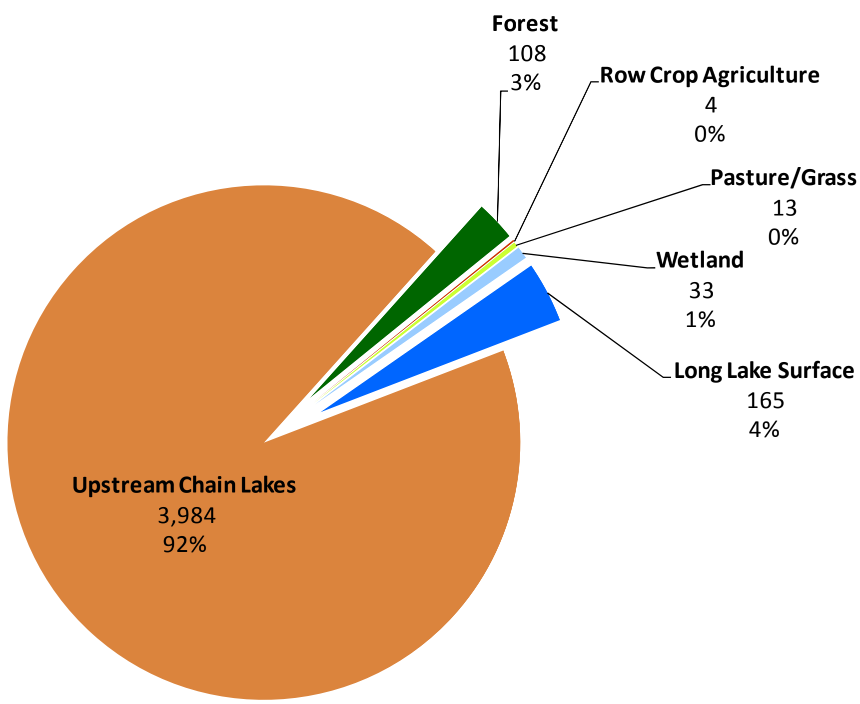

Figure 3.2-3. Long Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Aquatic Plants

Introduction

Although the occasional lake user considers aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, the plants are actually an essential element in a healthy and functioning lake ecosystem. It is very important that lake stakeholders understand the importance of lake plants and the many functions they serve in maintaining and protecting a lake ecosystem. With increased understanding and awareness, most lake users will recognize the importance of the aquatic plant community and their potential negative effects on it.

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*) In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the *periphyton* attached to them as their primary food source. The plants also provide cover for feeder fish and *zooplankton*, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreline erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas where plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by *phytoplankton*, which helps to minimize nuisance algal blooms.

Under certain conditions, a few species may become a problem and require control measures. Excessive plant growth can limit recreational use by deterring navigation, swimming, and fishing activities. It can also lead to changes in fish population structure by providing too much cover for feeder fish resulting in reduced numbers of predator fish and a stunted pan-fish population. *Exotic* plant species, such as Eurasian water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing *native* plants and reducing *species diversity*. These *invasive* plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

When plant abundance negatively affects the lake ecosystem and limits the use of the resource, plant management and control may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods. No aquatic plant management plan should only contain methods to control plants, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

Aquatic Plant Management and Protection

Important Note:
Even though most of these techniques are not applicable to Long Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake. The techniques applicable to Long Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

Many times an aquatic plant management plan is aimed at only controlling nuisance plant growth that has limited the recreational use of the lake, usually navigation, fishing, and swimming. It is important to remember the vital benefits that native aquatic plants provide to lake users and the lake ecosystem, as described above. Therefore, all aquatic plant management plans also need to address the enhancement and protection of the aquatic plant community. Below are general descriptions of the many techniques that can be utilized to control and enhance aquatic plants. Each alternative has benefits and limitations that are explained in its description. Please note that only legal and commonly used methods are included. For instance, the herbivorous grass carp (*Ctenopharyngodon idella*) is illegal in Wisconsin and rotovation, a process by which the lake bottom is tilled, is not a commonly accepted practice. Unfortunately, there are no "silver bullets" that can completely cure all aquatic plant problems, which makes planning a crucial step in any aquatic plant management activity. Many of the plant management and protection techniques commonly used in Wisconsin are described below.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now, including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that 30 feet. This action can be conducted up to 150 feet from shore. Please note that a permit is needed in all instances if wild rice is to be removed. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR.

Permits are required for chemical and mechanical manipulation of native and non-native plant communities. Large-scale protocols have been established for chemical treatment projects covering >10 acres or areas greater than 10% of the lake littoral zone and more than 150 feet from shore. Different protocols are to be followed for whole-lake scale treatments (≥160 acres or ≥50% of the lake littoral area). Additionally, it is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects (Jennings et al. 2003). The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreline. Removal of native plants and dead, fallen timbers from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreline sediments vulnerable to wave action caused by boating and wind (Jennings et al. 2003, Radomski and Goeman 2001, and Elias & Meyer 2003). Many homeowners significantly decrease the number of trees and shrubs along the water's edge in an effort to increase their view of the lake. However, this has been shown to locally increase water temperatures, and decrease infiltration rates of potentially harmful nutrients and pollutants. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife (Scheuerell and Schindler 2004).

In recent years, many lakefront property owners have realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a *shoreland buffer zone.* The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping. Simply not mowing within the buffer zone does wonders to restore some of the shoreland's natural function.

Enhancement activities also include additions of *submergent*, *emergent*, and *floating-leaf* plants within the lake itself. These additions can provide greater species diversity and may compete against exotic species.

Cost

The cost of native, aquatic and shoreland plant restorations is highly variable and depend on the size of the restoration area, planting densities, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other factors may include extensive grading requirements, removal of shoreland stabilization (e.g., rip-rap, seawall), and protective measures used to guard the newly planted area from wildlife predation, wave-action, and erosion. In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $4,200.

- The single site used for the estimate indicated above has the following characteristics:
  - An upland buffer zone measuring 35’ x 100’.
  - An aquatic zone with shallow-water and deep-water areas of 10’ x 100’ each.
  - Site is assumed to need little invasive species removal prior to restoration.
  - Site has a moderate slope.
  - Trees and shrubs would be planted at a density of 435 plants/acre and 1210 plants/acre, respectively.
  - Plant spacing for the aquatic zone would be 3 feet.
  - Each site would need 100’ of biolog to protect the bank toe and each site would need 100’ of wavebreak and goose netting to protect aquatic plantings.
  - Each site would need 100’ of erosion control fabric to protect plants and sediment near the shoreline (the remainder of the site would be mulched).
  - There is no hard-armor (rip-rap or seawall) that would need to be removed.
  - The property owner would maintain the site for weed control and watering.

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreline erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however Wisconsin law states that all plant fragments must be removed. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The raking method entails the use of a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the undesired plants.

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width. Please note that the use of powered cutters may require a mechanical harvesting permit to be issued by the WDNR.

When using the methods outlined above, it is very important to remove all plant fragments from the lake to prevent re-rooting and drifting onshore followed by decomposition. It is also important to preserve fish spawning habitat by timing the treatment activities after spawning. In Wisconsin, a general rule would be to not start these activities until after June 15th.

Cost

Commercially available hand-cutters and rakes range in cost from $85 to $150. Power-cutters range in cost from $1,200 to $11,000.

Advantages	*Disadvantages*
• Very cost effective for clearing areas around docks, piers, and swimming areas. • Relatively environmentally safe if treatment is conducted after June 15th. • Allows for selective removal of undesirable plant species. • Provides immediate relief in localized area. • Plant biomass is removed from waterbody.	• Labor intensive. • Impractical for larger areas or dense plant beds. • Subsequent treatments may be needed as plants recolonize and/or continue to grow. • Uprooting of plants stirs bottom sediments making it difficult to conduct action. • May disturb *benthic* organisms and fish-spawning areas. • Risk of spreading invasive species if fragments are not removed.

Bottom Screens

Bottom screens are very much like landscaping fabric used to block weed growth in flowerbeds. The gas-permeable screen is placed over the plant bed and anchored to the lake bottom by staking or weights. Only gas-permeable screen can be used or large pockets of gas will form under the mat as the result of plant decomposition. This could lead to portions of the screen becoming detached from the lake bottom, creating a navigational hazard. Normally the screens are removed and cleaned at the end of the growing season and then placed back in the lake the following spring. If they are not removed, sediments may build up on them and allow for plant colonization on top of the screen.

Cost

Material costs range between $.20 and $1.25 per square-foot. Installation cost can vary largely, but may roughly cost $750 to have 1,000 square feet of bottom screen installed. Maintenance costs can also vary, but an estimate for a waterfront lot is about $120 each year.

Advantages	*Disadvantages*
• Immediate and sustainable control. • Long-term costs are low. • Excellent for small areas and around obstructions. • Materials are reusable. • Prevents fragmentation and subsequent spread of plants to other areas.	• Installation may be difficult over dense plant beds and in deep water. • Not species specific. • Disrupts benthic fauna. • May be navigational hazard in shallow water. • Initial costs are high. • Labor intensive due to the seasonal removal and reinstallation requirements. • Does not remove plant biomass from lake. • Not practical in large-scale situations.

Water Level Drawdown

The primary manner of plant control through water level drawdown is the exposure of sediments and plant roots/tubers to desiccation and either heating or freezing depending on the timing of the treatment. Winter drawdowns are more common in temperate climates like that of Wisconsin and usually occur in reservoirs because of the ease of water removal through the outlet structure. An important fact to remember when considering the use of this technique is that only certain species are controlled and that some species may even be enhanced. Furthermore, the process will likely need to be repeated every two or three years to keep target species in check.

Cost

The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive. If a hydro-electric facility is operating on the system, the costs associated with loss of production during the drawdown also need to be considered, as they are likely cost prohibitive to conducting the management action.

Advantages	Disadvantages
• Inexpensive if outlet structure exists. • May control populations of certain species, like Eurasian water-milfoil for a few years. • Allows some loose sediment to consolidate, increasing water depth. • May enhance growth of desirable emergent species. • Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.	• May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant affects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*). • Permitting process may require an environmental assessment that may take months to prepare. • Unselective.

Mechanical Harvesting

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 6 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor. Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the latter route is chosen, it is especially important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Costs

Equipment costs vary with the size and features of the harvester, but in general, standard harvesters range between $45,000 and $100,000. Larger harvesters or stainless steel models may cost as much as $200,000. Shore conveyors cost approximately $20,000 and trailers range from $7,000 to $20,000. Storage, maintenance, insurance, and operator salaries vary greatly.

Advantages	***Disadvantages***
• Immediate results. • Plant biomass and associated nutrients are removed from the lake. • Select areas can be treated, leaving sensitive areas intact. • Plants are not completely removed and can still provide some habitat benefits. • Opening of cruise lanes can increase predator pressure and reduce stunted fish populations. • Removal of plant biomass can improve the oxygen balance in the littoral zone. • Harvested plant materials produce excellent compost.	• Initial costs and maintenance are high if the lake organization intends to own and operate the equipment. • Multiple treatments are likely required. • Many small fish, amphibians and invertebrates may be harvested along with plants. • There is little or no reduction in plant density with harvesting. • Invasive and exotic species may spread because of plant fragmentation associated with harvester operation. • Bottom sediments may be re-suspended leading to increased turbidity and water column nutrient levels.

Chemical Treatment

There are many herbicides available for controlling aquatic macrophytes and each compound is sold under many brand names. Aquatic herbicides fall into two general classifications:

1. *Contact herbicides* act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. *Systemic herbicides* spread throughout the entire plant and often result in complete mortality if applied at the right time of the year.

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Applying herbicides in the aquatic environment requires special considerations compared with terrestrial applications. WDNR administrative code states that a permit is required if "you are standing in socks and they get wet." In these situations, the herbicide application needs to be completed by an applicator licensed with the Wisconsin Department of Agriculture, Trade and Consumer Protection. All herbicide applications conducted under the ordinary high water mark require herbicides specifically labeled by the United States Environmental Protection Agency.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Some herbicides are applied at a high dose with the anticipation that the exposure time will be short. Granular herbicides are usually applied at a lower dose, but the release of the herbicide from the clay carrier is slower and increases the exposure time.

Below are brief descriptions of the aquatic herbicides currently registered for use in Wisconsin.

Fluridone (Sonar®, Avast!®) Broad spectrum, systemic herbicide that is effective on most submersed and emergent macrophytes. It is also effective on duckweed and at low concentrations has been shown to selectively remove Eurasian water-milfoil. Fluridone slowly kills macrophytes over a 30-90 day period and is only applicable in whole lake treatments or in bays and backwaters were dilution can be controlled. Required length of contact time makes this chemical inapplicable for use in flowages and impoundments. Irrigation restrictions apply.

Diquat (Reward®, Weedtrine-D®) Broad spectrum, contact herbicide that is effective on all aquatic plants and can be sprayed directly on foliage (with surfactant) or injected in the water. It is very fast acting, requiring only 12-36 hours of exposure time. Diquat readily binds with clay particles, so it is not appropriate for use in turbid waters. Consumption restrictions apply.

Endothall (Hydrothol®, Aquathol®) Broad spectrum, contact herbicides used for spot treatments of submersed plants. The mono-salt form of Endothall (Hydrothol®) is more toxic to fish and aquatic invertebrates, so the dipotassium salt (Aquathol®) is most often used. Fish consumption, drinking, and irrigation restrictions apply.

2,4-D (Navigate®, DMA IV®, etc.) Selective, systemic herbicide that only works on broad-leaf plants. The selectivity of 2,4-D towards broad-leaved plants (dicots) allows it to be used for Eurasian water-milfoil without affecting many of our native plants, which are monocots. Drinking and irrigation restrictions may apply.

Triclopyr (Renovate®) Selective, systemic herbicide that is effective on broad leaf plants and, similar to 2,4 D, will not harm native monocots. Triclopyr is available in liquid or granular form, and can be combined with Endothal in small concentrations (<1.0 ppm) to effectively treat Eurasian water-milfoil. Triclopyr has been used in this way in Minnesota and Washington with some success.

Glyphosate (Rodeo®) Broad spectrum, systemic herbicide used in conjunction with a *surfactant* to control emergent and floating-leaved macrophytes. It acts in 7-10 days and is not used for submergent species. This chemical is commonly used for controlling purple loosestrife (*Lythrum salicaria*). Glyphosate is also marketed under the name Roundup®; this formulation is not permitted for use near aquatic environments because of its harmful effects on fish, amphibians, and other aquatic organisms.

Imazapyr (Habitat®) Broad spectrum, system herbicide, slow-acting liquid herbicide used to control emergent species. This relatively new herbicide is largely used for controlling common reed (giant reed, *Phragmites*) where plant stalks are cut and the herbicide is directly applied to the exposed vascular tissue.

Cost

Herbicide application charges vary greatly between $400 and $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil. • Some herbicides can be used effectively in spot treatments.	• Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them. • Many herbicides are nonselective. • Most herbicides have a combination of use restrictions that must be followed after their application. • Many herbicides are slow-acting and may require multiple treatments throughout the growing season. • Overuse may lead to plant resistance to herbicides

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for either biocontrol insect.

However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water milfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian water milfoil.

Cost

Stocking with adult weevils costs about $1.20/weevil and they are usually stocked in lots of 1000 or more.

Advantages	***Disadvantages***
• Milfoil weevils occur naturally in Wisconsin. • Likely environmentally safe and little risk of unintended consequences.	• Stocking and monitoring costs are high. • This is an unproven and experimental treatment. • There is a chance that a large amount of money could be spent with little or no change in Eurasian water-milfoil density.

Wisconsin has approved the use of two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These beetles were imported from Europe and used as a biological control method for purple loosestrife. Many cooperators, such as county conservation departments or local UW-Extension locations, currently support large beetle rearing operations. Beetles are reared on live purple loosestrife plants growing in kiddy pools surrounded by insect netting. Beetles are collected with aspirators and then released onto the target wild population. For more information on beetle rearing, contact your local UW-Extension location.

In some instances, beetles may be collected from known locations (*cella* insectaries) or purchased through private sellers. Although no permits are required to purchase or release beetles within Wisconsin, application/authorization and release forms are required by the WDNR for tracking and monitoring purposes.

Cost

The cost of beetle release is very inexpensive, and in many cases is free.

Advantages	***Disadvantages***
• Extremely inexpensive control method. • Once released, considerably less effort than other control methods is required. • Augmenting populations many lead to long-term control.	• Although considered “safe,” reservations about introducing one non-native species to control another exist. • Long range studies have not been completed on this technique.

Analysis of Current Aquatic Plant Data

Aquatic plants are an important element in every healthy lake. Changes in lake ecosystems are often first seen in the lake's plant community. Whether these changes are positive, like variable water levels or negative, like increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways; there may be a loss of one or more species, certain life forms, such as emergents or floating-leaf communities may disappear from certain areas of the lake, or there may be a shift in plant dominance between species. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Long Lake; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in life-forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Long Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

In the end, this analysis indicates the species that dominate the plant community within the lake. Shifts in dominant plants over time may indicate disturbances in the ecosystem. For instance, low water levels over several years may increase the occurrence of emergent species while decreasing the occurrence of floating-leaf species. Introductions of invasive exotic species may result in major shifts as they crowd out native plants within the system.

Species Diversity

Species diversity is probably the most misused value in ecology because it is often confused with species richness. Species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because diversity also takes into account how evenly the species occur within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

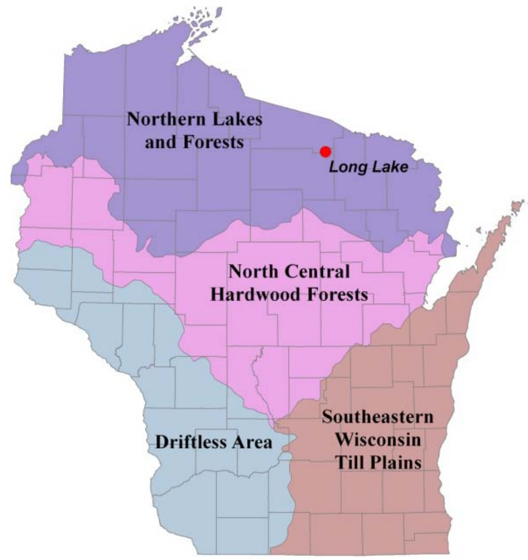

Figure 3.3-1. Location of Long Lake within the ecoregions of Wisconsin. After Nichols 1999.

A lake with high species diversity is much more stable than a lake with a low diversity. This is analogous to a diverse financial portfolio in that a diverse lake plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity.

One factor that influences species diversity is the "development factor" of the shoreline. This is not the degree of human development or disturbance, but rather it is a value that attempts to describe the nature of the habitat a particular shoreline may hold. This value is referred to as the shoreline complexity. It specifically analyzes the characteristics of the shoreline and describes to what degree the lake shape deviates from a perfect circle. It is calculated as the ratio of lake perimeter to the circumference of a circle of area equal to that of the lake. A shoreline complexity value of 1.0 would indicate that the lake is a perfect circle. The further away the value gets from 1.0, the more the lake deviates from a perfect circle. As shoreline complexity increases, species richness increases, mainly because there are more habitat types, bays and back water areas sheltered from wind.

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Long Lake will be compared to lakes in the same ecoregion and in the state (Figure 3.3-1).

Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality.

Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; while emergents include cattails, bulrushes, and arrowheads, and floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotics, curly-leaf pondweed and Eurasian water milfoil are the primary targets of this extra attention.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.3-2). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil

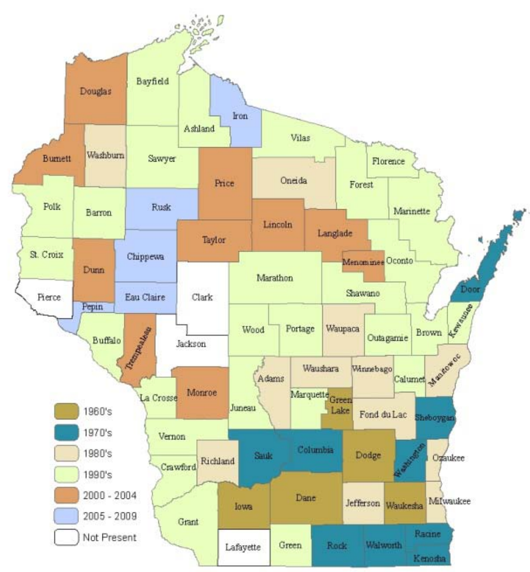

Figure 3.3-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2009 mapped by Onterra.

can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly – leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian water-milfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities within the lake. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

Because of its odd life-cycle, a special survey is conducted early in the growing season to inventory and map curly-leaf pondweed occurrence within the lake. Although Eurasian water milfoil starts to grow earlier than our native plants, it is at peak biomass during most of the summer, so it is inventoried during the comprehensive aquatic plant survey completed in mid to late summer.

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. In June 2009, a survey was completed on the Eagle River channel and Long Lake that focused upon curly-leaf pondweed. This meander-based survey did not locate any occurrences of curly-leaf pondweed. It is believed that this aquatic invasive species either does not occur in the Eagle River channel/Long Lake system or exists at an undetectable level. At present, no curly-leaf pondweed has ever been discovered in the Three Lakes Chain or Eagle River Chain. Kentuck Lake, located approximately 10 miles northeast of Long Lake, is the closest lake to the Eagle River channel/Long Lake system that currently contains curly-leaf pondweed.

Median Value This is the value that roughly half of the data are smaller and half the data are larger. A median is used when a few data are so large or so small that they skew the average value to the point that it would not represent the population as a whole.

Point-intercept surveys were conducted on the Eagle River channel and Long Lake in early July 2009 by Onterra (data found in Appendix E). Additional surveys were completed by Onterra to create the aquatic plant community map (Map 3) in mid-August 2009.

A total of 55 aquatic plant species (37 Eagle River channel, 44 Long Lake) were located during the point-intercept and aquatic plant mapping surveys (Table 3.3-1), three are considered non-native species: Eurasian water milfoil, hybrid cattail, and sweetflag. While Eurasian water milfoil and the hybrid cattail can be aggressive invaders, displacing native plant communities, sweetflag is considered to be 'naturalized', integrating itself into native plant communities without creating a significant ecological disturbance. These three species exist at a very low level within the Eagle River channel and Long Lake system and will be discussed in more detail in the Non-native Aquatic Plant Section below.

Besides Eurasian water milfoil, three other species of milfoil were also found in the Eagle River channel/Long Lake system. These three species, northern water milfoil, various-leaved water milfoil, and whorled water milfoil are all native to Wisconsin. Like Eurasian water milfoil, they have feathery foliage with individual leaves resembling a candelabra arranged in whorls around the stem. These leaves provide ample surface area for algae to grow and detritus to become trapped, providing valuable habitat for invertebrates. Various-leaved water milfoil was only observed in Long Lake from one occurrence, while whorled-water milfoil was only observed growing in the Eagle River channel.

Table 3.3-1. Aquatic plant species located in the Eagle River channel and Long Lake during 2009 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	Long Lake	Eagle River Channel
Emergent	*Acorus calamus*	Sweetflag	Exotic	I	
	Calla palustris	Water arum	9		I
	Carex comosa	Bristly sedge	5	I	
	Carex echinata	Star sedge	8	I	
	Dulichium arundinaceum	Three-way sedge	9	I	
	Eleocharis palustris	Creeping spikerush	6	X	
	Equisetum fluviatile	Water horsetail	7	I	
	Glyceria borealis	Northern manna grass	8	I	I
	Iris versicolor	Northern blue flag	5	I	
	Leersia oryzoides	Rice cut grass	3	I	
	Pontederia cordata	Pickerelweed	9	X	X
	Lythrum salicaria	Purple loosestrife	Exotic	I	
	Sagittaria latifolia	Common arrowhead	3	X	X
	Typha latifolia	Broad-leaved cattail	1		I
	Typha glauca	Hybrid cattail	Exotic	I	
	Schoenoplectus tabernaemontani	Softstem bulrush	4	X	I
FL	*Brasenia schreberi*	Watershield	7	X	X
	Nuphar variegata	Spatterdock	6	X	X
	Nymphaea odorata	White water lily	6	X	X
	Polygonum amphibium	Water smartweed	5		I
FL/E	*Sparganium angustifolium*	Narrow-leaf bur-reed	9	X	
	Sparganium eurycarpum	Common bur-reed	5	I	
	Sparganium fluctuans	Floating-leaf bur-reed	10	X	X
FF	*Lemna turionifera*	Turion duckweed	9		X
	Spirodela polyrhiza	Greater duckweed	5		X
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X
	Ceratophyllum echinatum	Spiny hornwort	10	X	
	Chara sp.	Muskgrasses	7	X	X
	Elatine minima	Waterwort	9		X
	Elodea canadensis	Common waterweed	3	X	X
	Heteranthera dubia	Water stargrass	6	X	
	Isoetes lacustris	Lake quillwort	8	X	X
	Megalodonta beckii	Water marigold	8	X	X
	Myriophyllum heterophyllum	Various-leaved water milfoil	7	X	
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	I	I
	Myriophyllum verticillatum	Whorled water milfoil	8		X
	Najas flexilis	Slender naiad	6	X	X
	Nitella sp.	Stoneworts	7	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X	X
	Potamogeton foliosus	Leafy pondweed	6		X
	Potamogeton gramineus	Variable pondweed	7	X	X
	Potamogeton praelongus	White-stem pondweed	8	X	
	Potamogeton pusillus	Small pondweed	7	X	
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton vaseyi	Vasey's pondweed	10	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Utricularia geminiscapa	Twin-stemmed bladderwort	9		X
	Utricularia intermedia	Flat-leaf bladderwort	9		X
	Utricularia vulgaris	Common bladderwort	7		X
	Vallisneria americana	Wild celery	6	X	X
SE	*Eleocharis acicularis*	Needle spikerush	5	X	
	Juncus pelocarpus	Brown-fruited rush	8	X	X
	Sagittaria graminea	Grass-leaved arrowhead	9	I	

FL = Floating-leaf, FL/E = Floating-leaf/Emeregent, FF = Free-floating, SE = Submergent/Emergent, X = Present, I = Incidental

Northern water milfoil was the third most frequently encountered species in the Eagle River channel and the fifth most frequently encountered species in Long Lake (Figures 3.3-2, 3.3-3). Northern water milfoil, arguably the most common milfoil species in Wisconsin lakes, is frequently found growing in soft sediments and high water clarity. These conditions can be observed in the Eagle River channel and Long Lake and likely can explain its prevalence. Northern water milfoil is often falsely identified as Eurasian water milfoil, especially since it is known to take on the 'reddish' appearance of Eurasian water milfoil as the plant reacts to increased sun exposure as the growing season progresses.

Photograph 3.3-1 Species of special concern, Vasey's pondweed (*Potamogeton vaseyi*). Shown are the floating leaves sub-tending the flower spikes above the water's surface.

During the aquatic plant surveys, ecologists located three species that are listed by the Natural Heritage Inventory Program as being species of 'special concern' in Wisconsin. These include spiny hornwort (*Ceratophyllum echinatum*), Vasey's pondweed (*Potamogeton vaseyi*) (Photograph 3.3-1), and twin-stemmed bladderwort (*Utricularia geminiscapa*). The populations for all three are secure globally, but spiny hornwort and Vasey's pondweed are considered imperiled in Wisconsin due to their rarity, while twin-stemmed bladderwort, though rare, is not considered to be imperiled.

Spiny hornwort is very similar in appearance to coontail (*Ceratophyllum demersum*), one of the most common aquatic plants in the Eagle River channel/Long Lake system and Wisconsin, and can be found growing in soft water lakes with good water clarity. Vasey's pondweed is a very delicate, narrow-leaved plant that produces floating leaves when fertile in shallower water (Photograph 3.3-1). Twin-stemmed bladderwort is usually found growing in quiet waters of soft water lakes and belongs to a genre of carnivorous plants that are so named for their small, sac-like 'bladders' they produce to trap and digest small zooplankton prey.

Vasey's pondweed was found in both the Eagle River channel and Long Lake, twin-stemmed bladderwort was only found growing in the Eagle River channel, and spiny hornwort was only found growing in Long Lake, . Figures 3.3-3 and 3.3-4 show that the populations of these three species are in good health within this system.

In the Eagle River channel, the most frequently encountered species were common waterweed, fern pondweed, northern water milfoil, and wild celery (Figure 3.3-3). Common waterweed was also the most frequently encountered species in Long Lake, followed by coontail, stoneworts, and fern pondweed (Figure 3.3-4). Common waterweed, coontail, and stoneworts lack true root structures, often making their locations within a water body subject to water movement and their tendency to become entangled in other plants, rocks, or debris.

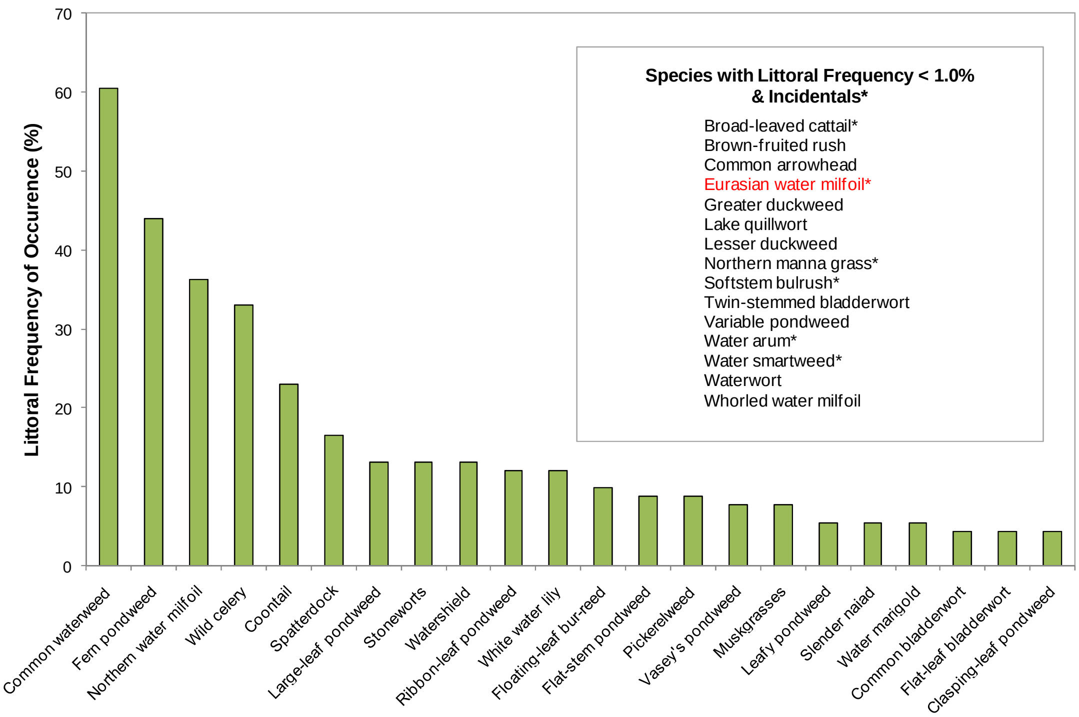

Figure 3.3-3 Eagle River channel aquatic plant littoral frequency. Created using data from 2009 aquatic plant surveys. Exotic species indicated with red.

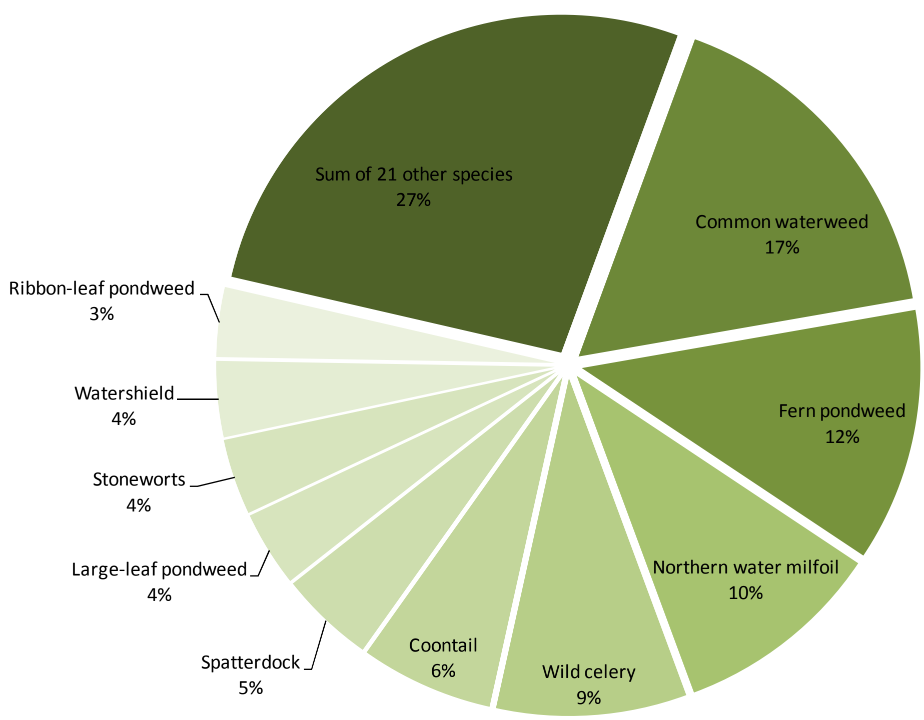

Figure 3.3-4. Eagle River channel aquatic plant relative frequency. Created using data from 2009 aquatic plant surveys. Exotic species indicated with red.

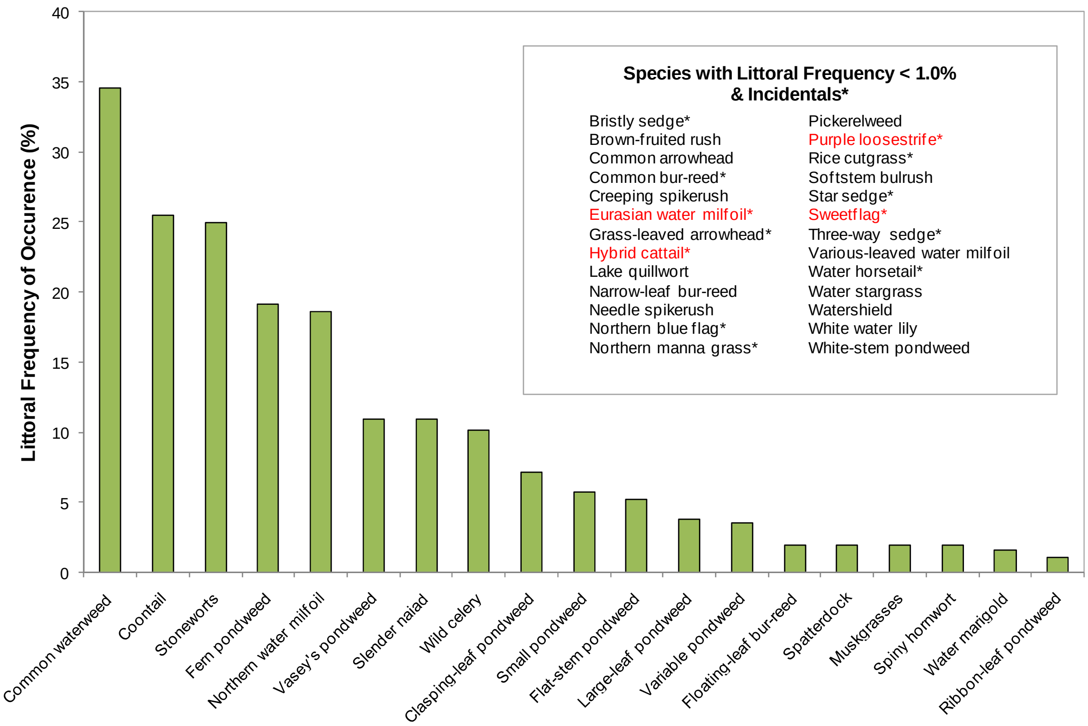

Figure 3.3-5 Long Lake aquatic plant littoral frequency. Created using data from 2009 aquatic plant surveys. Exotic species indicated with red.

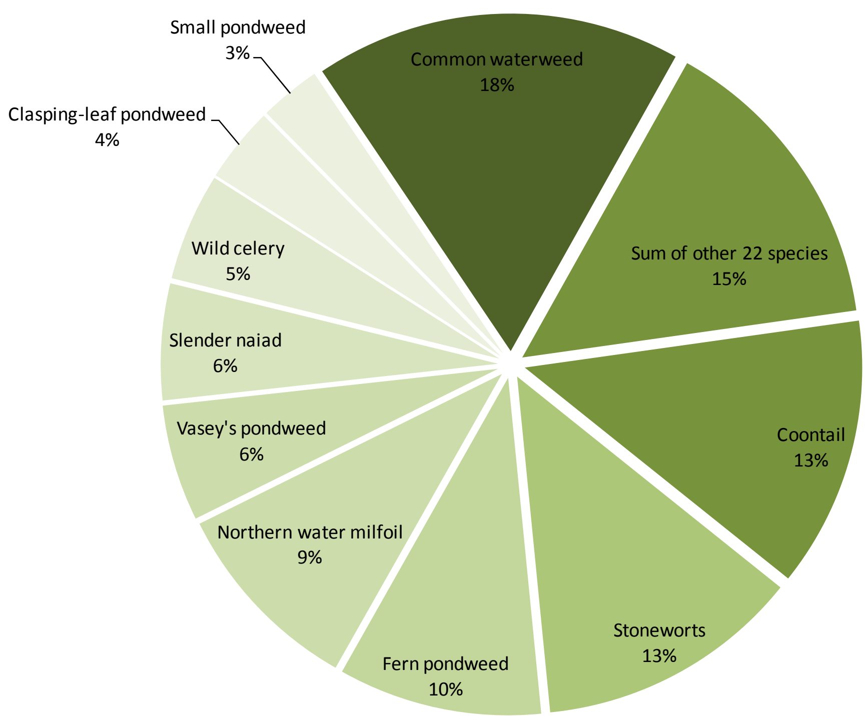

Figure 3.3-6 Long Lake aquatic plant relative frequency. Created using data from 2009 aquatic plant surveys. Exotic species indicated with red.

Being non-rooted, these plants receive the majority of their nutrients directly from the water and reduce nutrients available to free-floating algae, improving water clarity. Stoneworts are actually a genre of macroalgae, which are non-vascular plants lacking true roots and leaves and are often found growing in soft water lakes, like the Eagle River channel/Long Lake system. Fern pondweed, northern water milfoil, and wild celery are all rooted plants common throughout Wisconsin. These dominant plants provide valuable structural habitat for invertebrates and foraging opportunities for fish and other wildlife.

Plants were found growing to a maximum depth of 10 feet in the Eagle River channel and 14 feet in Long Lake, a testament to the high water clarity in this system. Of the point-intercept sampling locations that fell within the maximum depth range of plant growth, 89% in the Eagle River channel and 75% in Long Lake contained aquatic vegetation.

Figure 3.3-5 shows that both the Eagle River channel and Long Lake have high native species richness, well above the ecoregion and state level. The Eagle River channel/Long Lake system has many habitat types differing in substrate type, light availability, water depth, and water movement. While some aquatic plant species, such as elodea and coontail are habitat generalists growing in multiple habitat types, other species are habitat-specific like lake quillwort which is usually found growing in sandy substrates. All the varying habitat types within this system lead to a species-rich environment.

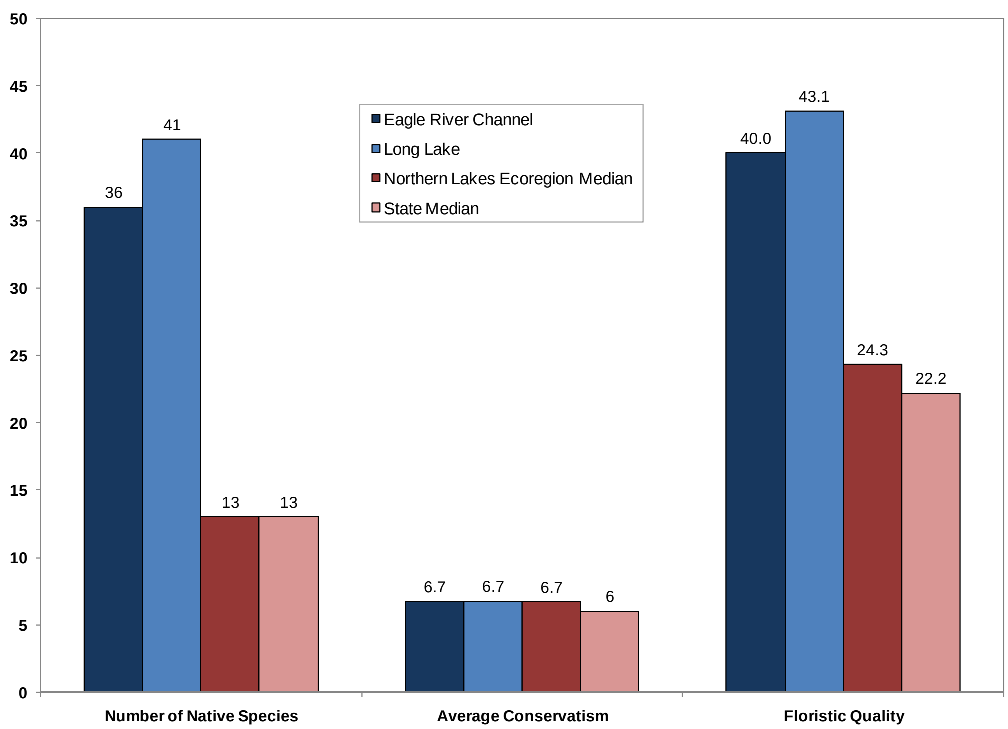

Figure 3.3-7 Eagle River channel and Long Lake Floristic Quality Assessment. Created using data from 2009 aquatic plant surveys. Analysis follows Nichols (1999).

Not only to the Eagle River channel and Long Lake have high species richness, they also have high species diversity. As discussed earlier, how evenly the species are distributed throughout the system also influences the diversity. The diversity index for both the Eagle River channel

(0.92) and Long Lake (0.90) indicate that both have a relatively even distribution (relative frequency) of plant species. The average conservatism value for the Eagle River channel (6.7) and Long Lake (6.7) are higher than the state median and equal to the ecoregion median. This shows that the plant communities of these systems are more indicative of a pristine condition than most lakes in the state, but they do contain some species that are tolerant to environmental disturbance.

Combining the species richness and average conservatism values to produce the Floristic Quality Index (FQI) results in exceptionally high value of 40.0 for the Eagle River channel and 43.1 for Long Lake (equation shown below), which are both well above the median values for the state and ecoregion (Figure 3.3-5). The value for Long Lake is slightly higher due to the higher species richness value.

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

The high quality of the Eagle River channel/Long Lake system's plant community is also indicated by the occurrence of emergent and floating-leaf plant communities that are found within the channel and the lake. The 2009 community maps indicate that approximately 23 acres (3.7%) of the 620-acre Long Lake and 8 acres (28.5%) of the 28-acre Eagle River channel contain these types of plant communities (Table 3.3-2). These communities provide valuable wildlife habitat and prevent shoreline erosion by dampening wave action. With these communities only being able to inhabit locations with specific habitat criteria (depth, substrate, prevailing winds, etc.) it is important to preserve them as much as possible.

Table 3.3-2. Eagle River channel and Long Lake acres of plant community types from the 2009 community mapping survey.

	Acres	
Plant Community	**Eagle River Channel**	**Long Lake**
Emergent	0.0	4.6
Floating-leaf	3.2	4.6
Mixed Floating-leaf and Emergent	5.2	13.7
Total	8.4	23.0

Continuing the analogy that the community map may represent a 'snapshot' of the important emergent and floating-leaf plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within the Eagle River channel/Long Lake system. This is important because these communities are often negatively affected by recreational use and shoreland development. Radomksi and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

In 2006, the WDNR conducted a point-intercept survey on the Eagle River channel and Long Lake using the same methodology and sampling points as the 2009 survey conducted by Onterra. It is important to note that field identification of particular plant species can be quite difficult at times, especially if the plant species are lacking key characteristics (e.g. flowers, fruit, winter buds). As part of the current project, representatives of all plant species located during the 2009 plant surveys were collected, prepared, and had their identifications verified (confirmed and stored in a state-wide database) by the University of Wisconsin – Stevens Point Herbarium.

Aquatic plant frequencies of occurrence were compared from the 2006 and 2009 surveys on both the Eagle River channel and Long Lake. Table 3.3-3 displays the changes in frequencies of the submerged aquatic plant species that were found in both the 2006 and 2009 surveys. Statistical analysis is used by scientists to determine if an observed difference is sufficient to be attributed to a particular factor or if the difference may have occurred randomly. If the difference is sufficient, it is considered to be *significantly different*, if it is not sufficient, it is considered to be *insignificantly different*. In the end, a significant different can be attributed to some factor, while and insignificant difference can only be attributed to random variation.

As table 3.3-5 shows, coontail, common waterweed, fern pondweed and northern water milfoil have all seen a significant increase in occurrence in both the Eagle River channel and Long Lake from 2006 to 2009. The northern water milfoil from Long Lake was sent in for DNA to determine if it was a hybrid with the invasive Eurasian water milfoil. The results of the DNA analysis indicated that the plants were pure northern water milfoil. In the Eagle River channel, the percent of point-intercept sampling points that fell within the maximum depth of aquatic plant growth that contained aquatic vegetation increased from 74% in 2006 to 89% in 2009, and in Long Lake increased from 66% in 2006 to 74% in 2009.

Falling water levels can often cause an increase in aquatic plant occurrence. As the water level drops, areas that were once too deep and lacked sufficient amounts of light to support plant growth are now available for plant colonization. However, the water level of the Eagle River channel/Long Lake system as measured at the Burnt Rollways Dam has remained relatively constant from 2006 to 2009. Increasing water clarity can also lead to higher occurrences of aquatic plants. As water clarity increases, the light necessary to sustain aquatic plants is able to reach deeper water. This possibility is likely as the observed maximum depth of plant growth increased from 12 feet in 2006 to 14 feet in 2009, indicating plants have colonized deeper areas.

Table 3.3-3. Select native plant species change in occurrence on the Eagle River channel and Long Lake from 2006 to 2009 aquatic plant surveys. Statistical significance is determined by Chi-square distribution analysis (alpha = 0.05).

Eagle River Channel

Scientific Name	Common Name	Percent Change	2006-2009
Ceratophyllum demersum	Coontail	425.0	▲
Elodea canadensis	Common waterweed	37.5	▲
Heteranthera dubia	Water stargrass	-100.0	▽
Juncus pelocarpus	Brown-fruited rush	200.0	△
Megalodonta beckii	Water marigold	150.0	△
Myriophyllum sibiricum	Northern water milfoil	560.0	▲
Myriophyllum verticillatum	Whorled water milfoil	0.0	-
Najas flexilis	Slender naiad	0.0	-
Nitella sp.	Stoneworts	100.0	△
Potamogeton amplifolius	Large-leaf pondweed	200.0	▲
Potamogeton crispus	Curly-leaf pondweed	-100.0	▽
Potamogeton gramineus	Variable pondweed	0.0	-
Potamogeton richardsonii	Clasping-leaf pondweed	0.0	-
Potamogeton robbinsii	Fern pondweed	471.4	▲
Potamogeton zosteriformis	Flat-stem pondweed	166.7	△
Vallisneria americana	Wild celery	-23.1	▽
Small Pondweeds		0.0	-

Long Lake

Scientific Name	Common Name	Percent Change	2006-2009
Ceratophyllum demersum	Coontail	244.4	▲
Eleocharis acicularis	Needle spikerush	-66.7	▽
Elodea canadensis	Common waterweed	41.6	▲
Juncus pelocarpus	Brown-fruited rush	300.0	△
Megalodonta beckii	Water marigold	20.0	△
Myriophyllum sibiricum	Northern water milfoil	183.3	▲
Najas flexilis	Slender naiad	-23.1	▽
Nitella sp.	Stoneworts	279.2	▲
Potamogeton alpinus	Alpine pondweed	-100.0	▽
Potamogeton amplifolius	Large-leaf pondweed	-22.2	▽
Potamogeton gramineus	Variable pondweed	8.3	△
Potamogeton richardsonii	Clasping-leaf pondweed	333.3	▲
Potamogeton robbinsii	Fern pondweed	311.8	▲
Potamogeton zosteriformis	Flat-stem pondweed	171.4	▲
Vallisneria americana	Wild celery	-54.9	▼
Small Pondweeds		-10.8	▽

▲ or ▼ = Significant Change
△ or ▽ = Insignificant Change

Non-native Aquatic Plants

Eurasian water milfoil

In the summer of 2006, Eurasian water milfoil (Eurasian water milfoil) was located approximately 0.25 miles upstream from the Burnt Rollways Dam. As a result of that finding, the Wisconsin Department of Natural Resources (WDNR) issued an Aquatic Invasive Species (AIS) Early Detection and Rapid Response Grant to the Town of Three Lakes.

In the spring of 2007, Onterra ecologists surveyed the area and created a 0.5-acre treatment site over a scattered occurrence of Eurasian water milfoil. That area was treated in May 2007. The post treatment survey completed that summer yielded no Eurasian water milfoil within the treatment area, but a couple small clumps were located immediately across the channel. The area was monitored by volunteers from the Three Lakes Waterfront Association, Inc. (TLWA) from the spring of 2007 through the summer of 2008. In August of 2008, TLWA monitors located scattered occurrences for Eurasian water milfoil within much of the channel and as a result contacted the WDNR for guidance.

On September 5, 2008, Onterra ecologist Tim Hoyman once again visited the area and mapped numerous occurrences of Eurasian water milfoil between the Burnt Rollways Dam and the northern boundary of Long Lake. An 11.8-acre treatment area consisting of single plants and small colonies as well as a relatively larger colony of dominant Eurasian water milfoil was created and later treated in the spring of 2009 (Map 4). No Eurasian water milfoil was observed within the treatment areas during the summer 2009 surveys, indicating the treatment was very successful. However, during the curly-leaf pondweed survey, Onterra ecologists discovered a single Eurasian water milfoil plant growing near the western shoreline of Long Lake just south of the boat landing on Van Bussum Lane. This plant was manually removed with a rake and sent to the UW-Stevens Point Herbarium and was verified as Eurasian water milfoil. No other occurrences of Eurasian water milfoil were found in Long Lake.

In early October 2010, Onterra ecologists visited the channel and found 8 single Eurasian water milfoil plants and 1 small clump of plants (Map 5) which were able to be manually removed with a rake.

During the September 2011, Onterra ecologists once again visited the Eagle River Channel to search for Eurasian water milfoil. During this visit, only a few scattered plats were located, which were all removed with a rake. No treatment was recommended for the spring of 2012.

Purple loosestrife

Purple loosestrife was located on the eastern shore of Long Lake during the 2009 community mapping survey (Map 3). In this area, there were approximately 30 plants observed growing in clumps. Purple loosestrife is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources.

The infestation of purple loosestrife on Long Lake is likely a relatively recent occurrence. There are a number of effective control strategies for combating this aggressive plant, including herbicide application, biological control by beetles, and manual hand removal. At this time, hand removal by volunteers is likely the best option as it would decrease costs significantly. Additional purple loosestrife monitoring would be required to ensure the eradication of the plant from the shorelines of Long Lake.

3.4 Long Lake Fishery

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2010 & GLIFWC 2010A and 2010B).

Table 3.4-1. Gamefish present in the Long Lake with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie	Pomoxis nigromaculatus	7	May - June	Near Chara or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill	Lepomis macrochirus	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass	Micropterus salmoides	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge	Esox masquinongy	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike	Esox lucius	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed	Lepomis gibbosus	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass	Ambloplites rupestris	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass	Micropterus dolomieu	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye	Sander vitreus	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch	Perca flavescens	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Long Lake Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), open water fishing was the second highest ranked enjoyable activity on Long Lake and the Eagle River Channel (Question #10). Approximately 64% of these same respondents believed that the quality of fishing on the lake was either fair or good on Long Lake (Question #9); however approximately 71% believe that the quality of fishing has remained the same or gotten worse since they started fishing the lake (Question #11). When asked about improving fish habitat on Long Lake, 62% of respondents believed it should be improved (Question #13), though 21% of respondents indicated interest in hosting an improvement project on their shoreline (Question #15)

Table 3.4-1 (above) shows the popular game fish that are present in the system. Management actions that have taken place on Long Lake according include herbicide applications to control Eurasian water milfoil on the Eagle River Channel. Like these prior applications, future applications will occur in May when the water temperatures are below 60°F. It is important to understand the effect the chemical has on the spawning environment which would be to remove the submergent plants that are actively growing at these low water temperatures. Yellow perch is a species that could potentially be affected by early season herbicide applications, as the treatments could eliminate nursery areas for the emerged fry of these species. Muskellunge is another species that may be impacted by early season treatments as water temperatures and spawning locations often overlap.

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.4-1). Lac Vieux Desert falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified systems. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then an "allowable catch" is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% of a lake's fishing stock, but may vary on an individual lake basis. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The allowable catch number is then reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level". The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent, or declaration. This result is

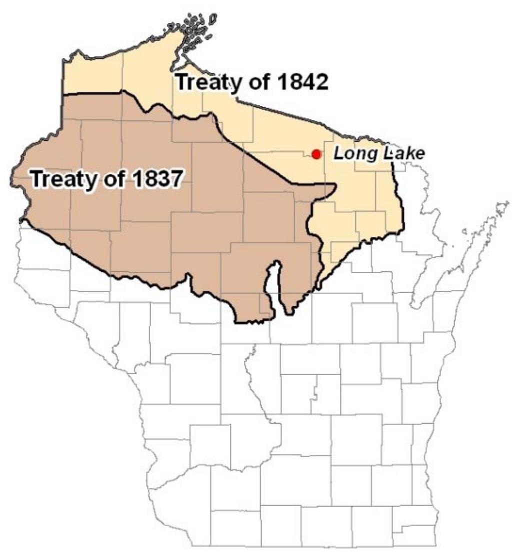

Figure 3.4-1. Location of Long Lake within the Native American Ceded Territory (GLIFWC 2010A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

called the quota, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal quota and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2 fish daily bag limit for hook-and-line anglers (USDI 2007).

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2010B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly quota is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the quota is met or the season ends.

Walleye and muskellunge are the only two species taken during the open water spear fish harvest. Walleye open water spear harvest records are provided in Table 3.4-2 and Figure 3.4-2, while muskellunge open water spear harvest records are provided in Table 3.4-3. From these records, it is clear that walleye are the most commonly sought after species in Long Lake, as only a two muskies has been harvested since 1998.

One common misconception is that the spear harvest targets the large spawning females. Table 3.4-2 and Figure 3.4-2 clearly show that the opposite is true with only 6.4% of the total walleye harvest (63 fish) since 1998 comprising of female fish on Long Lake. Tribal spearers may only take two walleyes over twenty inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIWC 2010B). This regulation limits the harvest of the larger, spawning female walleye.

Because Long Lake is located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to Long Lake. In 2010, the daily bag limit remained at 3 for the lake.

Table 3.4-2. Open water spear harvest data of walleye for Long Lake (GLIFWC annual reports for Long Lake, Krueger 1998-2009.

Year	Tribal Quota	Tribal Harvest	%Quota	Mean Length* (in)	%Male*	%Female*	%Unknown
1998	209	27	12.9	15.4	92.6	3.7	3.7
1999	206	0	0.0				
2000	210	120	57.1	12.9	95.8	3.3	0.8
2001	215	66	30.7	13.8	83.3	16.7	0.0
2002	215	51	23.7	13.6	90.2	0.0	9.8
2003	215	7	3.3	12.7	100.0	0.0	0.0
2004	215	60	27.9	14.0	76.7	16.7	6.7
2005	205	128	62.4	13.5	77.3	13.3	9.4
2006	207	133	64.3	13.1	85.0	0.8	14.3
2007	208	208	100.0	13.4	90.4	9.6	0.0
2008	145	144	99.3	11.9	89.6	3.5	6.9
2009	202	201	99.5	12.1	84.9	2.6	12.5

*Based on Measured Fish

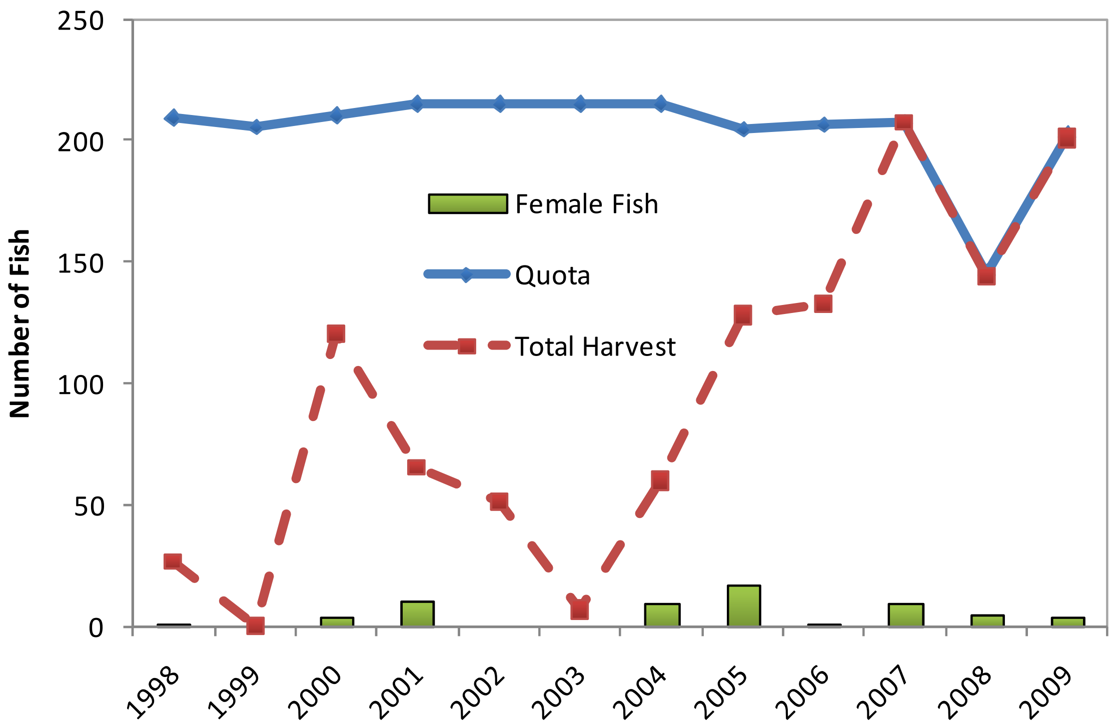

Figure 3.4-2. Walleye spear harvest data. Annual total walleye harvest and female walleye harvest are displayed since 1998 from GLIFWC annual reports for Long Lake (Krueger 1998-2009).

Table 3.4-3. Open water spear harvest data of muskellunge for Long Lake (GLIFWC annual reports for Long Lake, Krueger 1998-2009).

Year	Tribal Quota	Total Harvest	% Quota	Mean Length* (in)
1998	8	0	0.0	
1999	8	0	0.0	
2000	7	0	0.0	
2001	7	0	0.0	
2002	7	0	0.0	
2003	7	0	0.0	
2004	7	0	0.0	
2005	8	0	0.0	
2006	8	1	12.5	41.5
2007	8	0	0.0	
2008	8	1	12.5	33.2
2009	8	0	0.0	

Long Lake Fish Stocking

To assist in meeting fisheries management goals, the WDNR may stock fish in a waterbody that were raised in nearby permitted hatcheries. Stocking of a lake is sometimes done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Fish can be stocked as fry, fingerlings or even as adults.

Muskellunge have been actively stocked in recent years by the WDNR (Table 3.4-4) in an effort to influence the populations of these species. Under the WDNR's classification of muskellunge waters, Long Lake ranks as a Class A2, Category 2 angling lake. The Class 2 distinction means that Long Lake can provide consistent angling action, with relatively large numbers of muskellunge, however larger fish make up a smaller percent of the total population. Additionally, the Category 2 label indicates that the muskellunge has some natural reproduction, however some stocking is done on the lake to supplement this natural population.

Indeed stocking of muskellunge in Long Lake has been done historically and in recent years. Walleye have not been stocked since 1990. Table 3.4-4 displays WDNR stocking records for these species. In 1996-1998, a number of panfish (mostly bluegill and pumpkinseed) were field transferred from several nearby lakes which had over-abundant and stunted populations (John Kubisiak, per. comm.). The goal with this project was to thin out the population, thereby improving growth rates, in the source lakes and also to establish a better bluegill fishery in the Three Lakes Chain. Source lakes included Stella Lake (Oneida Co.), Lake of the Hills (Vilas Co.) and Maple Lake of the Three Lakes Chain of Lakes.

Long Lake Substrate Type

According to the point-intercept survey conducted by Onterra, 66% of the substrate sampled in the littoral zone on Long Lake was muck, with 28% being classified as sand and 6% being classified as rock. Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Muskellunge is one species that does not provide parental care to its eggs (Becker 1983). Muskellunge broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so they do not get buried in sediment and suffocate. Walleye is another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

Table 3.4-4. WDNR stocking data available from 1972 to 2010 (WDNR 2011).

Year	Species	Age Class	# Stocked	Avg. Length (inches)
1984	Muskellunge	Fingerling	300	11
1986	Muskellunge	Fingerling	1,200	11.5
1988	Muskellunge	Fingerling	1,200	10.67
1990	Muskellunge	Fingerling	1,200	11.5
1991	Muskellunge	Fingerling	420	12
1992	Muskellunge	Fingerling	1,200	10.48
1993	Muskellunge	Fingerling	600	12
1996	Muskellunge	Fingerling	600	10.8
1998	Muskellunge	Large Fingerling	600	12.5
2000	Muskellunge	Large Fingerling	600	10.9
2002	Muskellunge	Large Fingerling	310	10.2
2004	Muskellunge	Large Fingerling	240	10.3
2006	Muskellunge	Large Fingerling	155	9.9
2008	Muskellunge	Large Fingerling	155	10.1
2010	Muskellunge	Large Fingerling	140	12.9
2012	Muskellunge	Large Fingerling	155	10.4
1972	Walleye	Fingerling	15,000	3
1974	Walleye	Fingerling	18,200	3
1975	Walleye	Fingerling	36,200	-
1990	Walleye	Fingerling	5,115	2
1996	Bluegill	Adult	1,330	4.6
1997	Bluegill	Adult	1,586	4.6
1998	Bluegill	Adult	750	4.8
1996	Pumpkinseed	Adult	148	4.6
1997	Pumpkinseed	Adult	193	-

4.0 SUMMARY AND CONCLUSIONS

The design of this project was intended to fulfill three objectives;

1) Collect baseline data to increase the general understanding of Long Lake and the Eagle River channel ecosystem.
2) Collect detailed information regarding the presence of any invasive plant species within the lake, and gain an understanding about the extent of Eurasian water milfoil within the Eagle River channel leading towards Burnt Rollways Dam.
3) Collect sociological information from Long Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

The three objectives were fulfilled during the project and have led to a good understanding of much of the Long Lake and Eagle River channel ecosystem, the folks that care about the system, and what needs to be completed to protect and enhance it.

As learned during the course of this project, Long Lake is a fairly healthy, productive, and clean waterbody. There are a number of reasons why this is so, and the first begins with the watershed, or drainage basin contributing to the lake. As mentioned in the Watershed Section, the immediate watershed is relatively small when compared to the size of the lake. However, Long Lake is situated downstream of a large chain of lakes, and as a result, the watershed is about 115 times larger than the lake. Because the watershed is so immense, it is likely that Long Lake will always have somewhat stained water, and a moderate nutrient content. Luckily, most of the contributing watershed is forested, which reduces nutrient and sediment input to the lakes of the Three Lakes Chain by filtering runoff water before it enters the lake. Additionally, most of the water is flushed through Long Lake at a fairly rapid rate, moving these pollutants downstream before they can substantially accumulate.

Considering the large contributing watershed, the water quality of Long Lake is in fair condition. Secchi disk depths average around 7 feet, and the phosphorous content in the water column is moderate – not quite enough to spur intense algae blooms, as given by the chlorophyll-*a* content of the lakes; but enough to feed moderate algae production, which in turn supports the base of a healthy food chain. As discussed in the Water Quality Section, Long Lake is likely impacted heavily by annual weather and climactic conditions, of which the most influential factor would likely be precipitation.

The nutrient content of Long Lake is also ample to support an incredibly diverse array of aquatic plants. During Onterra's surveys, ecologists found 55 native plant species between Long Lake and the Eagle River channel. As highlighted in the Aquatic Plant Section, there are many different species from a variety of community types – emergent, submergent, and floating-leaf. These many species types provide diverse habitat, spawning territory and food sources for both aquatic and terrestrial animals, as well as protecting the lake shoreline from erosion. Additionally, having a diverse and healthy aquatic plant community will help to prevent colonial expansion from invasive submergent plants such as Eurasian water milfoil.

From analyzing the results of the stakeholder survey, it is clear that there are a number of concerns that stakeholders have, including the annual Native American spearfishing season and aquatic invasive species. Additionally, it is apparent that user conflicts exist on the lake with respect to boating use. It must be remembered that there are many groups of people that are enjoying the lake the way they see fit. While there is typically an annual spear harvest that takes place on Long Lake, as explained in the Fisheries Section this process is a highly regulated one. Additionally, WDNR and GLIFWC biologists work together to ensure that Native American spear harvesting is not detrimental to the walleye population of the lake. This process is scientifically driven, and is supported by both WDNR and GLIFWC monitoring of populations, as well as surveying of fishing activities by all anglers.

Operators of personal watercraft (PWC) or larger boats must remember that there are those that enjoy peaceful, quiet times on the lake. At the same time, those individuals who seek quiet time on the lake must remember that operators of larger boats have the right to recreate in this manner as well. Common courtesy comes into play here – those wishing to operate larger boats and personal water craft must abide by State of Wisconsin boating regulations, as well as local ordinance. An Advisory Committee was created in 2010 to negotiate boater safety on the Three Lakes Chain and debate 2009 Wisconsin Act 31, a rule prohibiting greater than slow-no-wake speed within 100 feet of the shoreline (*note: this rule does not apply to personal watercraft, which must operate at slow-no-wake speeds within 200 feet of the shoreline*). The committee ultimately became equally divided on the issue of this new rule, weighing the costs of lost recreational opportunity versus the safety and environmental benefits. Ultimately, the Town of Three Lakes has excluded the Three Lakes Chain of Lakes from Act 31, but has enacted numerous “zones for quiet sports”, “shallow water”, and “caution area” zones. In addition, the group identified several lakes as recommended “canoe and kayak recreational lakes” and several key zones as recommended “canoe and kayak recreational areas”. The committee also inspected and recommended placement of slow-no-wake buoys throughout the chain. Finally, it was proposed that a bullet-point safety brochure be developed which could be distributed to residents and tourists.

While the Town of Three Lakes has excluded itself from Act 31 and put other boating safety protocols in place, it is important to remember the environmental rationale for which these rules are enacted. Boating close to the shoreline can cause shoreline erosion, stir up lake bottom sediments causing turbidity, and release nutrients such as phosphorus which can contribute to algal growth. In addition, boating in these areas can be harmful to fish habitat as propellers uproot emergent plant populations. Although it is allowable to do so, operating watercraft at greater than slow-no-wake speeds close to the shoreline should be avoided on the Three Lakes Chain if possible, due to these ecological concerns. For additional watercraft regulations, stakeholders should investigate local ordinances in addition to consulting the Wisconsin Boating Regulations and Handbook, available at WDNR offices and most outdoor sporting goods stores.

A major challenge for Long Lake will be the monitoring and control of Eurasian water milfoil on the lakes north end (within the Eagle River channel). As described within the Aquatic Plant Section (and further elaborated upon in the Implementation Plan) monitoring of the channel by numerous entities has occurred for the past 5+ years. Volunteer efforts will be crucial in locating new infestations, should they occur, and relaying that information to WDNR and other professionals. Of particular importance will be to continue the monitoring of boats passing from the Lower Eagle River Chain to the Three Lakes Chain via the tracked boat-lift system. The Implementation Plan that follows this section describes the necessary steps to be taken by the TLWA in order to keep this invasive plant in check.

5.0 IMPLEMENTATION PLAN

The intent of this project was to complete a *comprehensive* management plan for Long Lake. As described in the proceeding sections, a great deal of study and analysis were completed involving many aspects of the ecosystem. This section stands as the actual "plan" portion of this document as it outlines the steps the TLWA will follow in order to manage Long Lake, its watershed, and the association itself.

The implementation plan is broken into individual *Management Goals*. Each management goal has one or more management actions that if completed, will lead to the specific management goal in being met. Each management action contains a timeframe for which the action will be taken, a facilitator that will initiate or carry out the action, a description of the action, and if applicable, a list of prospective funding sources and specific actions steps.

Management Goal 1: Continue to Control Eurasian Water Milfoil and Prevent Other Aquatic Invasive Species Infestations on the Three Lakes Chain of Lakes

Management Action: Continue Clean Boats Clean Waters watercraft inspections at Burnt Rollways boat lift and other Long Lake public access locations.

Category: Prevention & Education.

Timeframe: In progress.

Facilitator: Long Lake Planning Committee in coordination with TLWA Clean Boats/Clean Waters coordinators.

Description: A significant number of boats enter the Three Lakes Chain at the Burnt Rollways boat lift. These boats come from many surrounding waterbodies, some of which may be infested with aquatic invasive species. The Clean Boats/Clean Waters (CBCW) program of the TLWA supplies both paid and volunteer boat inspectors at the boat lift to assure removal of vegetation from boats coming over the dam. Eurasian water milfoil has been found in the Eagle River channel from the dam south to Long Lake. These infestations have been treated successfully but there is no assurance that more will not be found. In addition to the boat lift there are boat landings at the Burnt Rollways location as well as another off of Van Bussum Road. The Van Bussum Road landing typically sees increased use because of the slow/no wake from the dam to Long Lake.

The CBCW boat inspections at these public access points reduce Eurasian water milfoil from entering Long Lake and also from being transported to other lakes. Additionally, the intent of the boat inspections is to prevent other invasive species from entering the lake through the public access points. CBCW inspectors cover the landing during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on our lakes and educating people about how they are the primary vector of its spread.

Action Steps:

1. Members of association attend CBCW training session through CBCW coordinator to update their skills to current standards. This session should be attended in the spring/early summer prior to inspections.
2. Begin inspections during high-risk weekends, such as times of special town events, fishing tournaments or holidays.
3. Report results to WDNR and TLWA.
4. Promote enlistment and training of Long Lake and other Three Lakes Chain volunteers to broaden volunteer base and ensure program survival.

Management Action: Coordinate monitoring for Aquatic Invasive Species through continuation of Adopt-A-Shoreline program.

Category: Prevention & Education.

Timeframe: In progress.

Facilitator: Long Lake Planning Committee in coordination with Lake Captains and Long Lake residents.

Description: In lakes with Eurasian water milfoil or other invasive species, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, potentially eradication. While efforts to control Eurasian water milfoil within the Eagle River channel of Long Lake have been successful, eradication of this hearty and resilient invasive plant is very difficult. Therefore, it is crucial for locations of new plants to be promptly identified before they reproduce.

The Three Lakes Waterfront Association has initiated a strategy in which lake residents are coordinated to search the lakeshore area for invasive plant species. These efforts take place on Long Lake as well as the rest of the Three Lakes Chain. A Lake Captain (a member of the planning committee) is responsible for recruiting Long Lake home owners to participate in these shoreline patrols. . Although most shorelines have been patrolled on an annual basis over the last several years, more volunteers are needed to assure future coverage. These volunteers also intensively cover the area near the Burnt Rollways Dam, as this is a point of special interest due to past infestations being located here.

Action Steps:

1. Volunteers from TWLA update their skills by attending a spring/early summer training session conducted by WDNR/UW-Extension through the AIS Coordinator for Oneida County (currently Michele Sadauskas – 715.365.2750).
2. Trained volunteers recruit and train additional association members.
3. Complete lake surveys following protocols.
4. Report results to WDNR and TLWA.

Management Goal 2: Increase the Three Lakes Waterfront Association's Capacity to Communicate with and Educate Lake Stakeholders

Management Action: Support an Education Committee to promote safe boating, water quality, public safety, and quality of life on Long Lake.

Timeframe: Begin summer 2011.

Facilitator: Board of Directors to form Education Committee.

Description: Education represents an effective tool to address issues that impact water quality such as lake shore development, lawn fertilization, and other issues such as air quality, noise pollution, and boating safety. An Education Committee will be created to promote lake protection through a variety of educational efforts.

Currently, the TLWA regularly distributes newsletters to association members and has launched a website (http://www.threelakeswaterfrontassociation.com) which allow for exceptional communication within the lake group. This level of communication is important within a management group because it builds a sense of community while facilitating the spread of important association news, educational topics, and even social happenings. It also provides a medium for the recruitment and recognition of volunteers. Perhaps most importantly, the dispersal of a well written newsletter can be used as a tool to increase awareness of many aspects of lake ecology and management among association members. By doing this, meetings can often be conducted more efficiently and misunderstandings based upon misinformation can be avoided. Educational pieces within the association newsletter may contain monitoring results, association management history, as well as other educational topics listed below.

In addition to creating regularly published association newsletters, a variety of educational efforts will be initiated by the Education Committee. These may include educational materials, awareness events and demonstrations for lake users as well as activities which solicit local and state government support.

Example Educational Topics:

- Specific topics brought forth in other management actions
- Aquatic invasive species identification & monitoring
- Boating safety and ordinances (slow-no-wake zones and hours)
- Catch and release fishing
- Littering (particularly on ice)
- Noise, air, and light pollution
- Shoreland restoration and protection
- Septic system maintenance
- Fishing Rules

Action Steps:

1. Recruit volunteers to form Education Committee.
2. Investigate if WDNR small-scale Lake Planning Grant would be appropriate to cover initial setup costs.

3. The TLWA Board will identify a base level of annual financial support for educational activities to be undertaken by the Education Committee.

Management Goal 3: Facilitate Partnerships with Other Management Entities and Stakeholders

Management Action: Enhance TLWA's involvement with other entities that have a hand in managing (management units) or otherwise utilizing Long Lake.

Timeframe: Begin summer 2011.

Facilitator: Board of Directors to appoint TLWA representatives.

Description: As stated on the association website, the purpose of the TLWA is *to preserve and protect our waterways and shorelines…today and for generations to come*. The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. Some of these entities are governmental while other organizations are similar to the TLWA in that they rely on voluntary participation.

It is important that the TLWA actively engage with all management entities to enhance the association's understanding of common management goals and to participate in the development of those goals. This also helps all management entities understand the actions that others are taking to reduce the duplication of efforts. While not an inclusive list, the primary management units regarding Long Lake are the WDNR, Three Lakes Town Board of Supervisors, Oneida County Land and Water Conservation Department (OCLWCD), and Oneida County Lakes and Rivers Association (OCLRA). The Honey Rock Camp owns 800 acres of forested land along Long Lake, including a significant amount of shoreline. And finally, the Unified Lower Eagle River Chain of Lakes Commission oversees nine waterbodies that are located directly downstream of Long Lake. Each entity will be specifically addressed below.

<u>Honey Rock Camp</u> The Honey Rock Camp owns a considerable amount of land along Long Lake. This land is minimally developed, and because of this there are multiple benefits to the lake (minimal shoreline disturbance, filtering of water by the forests and wetlands, etc.). Managers and employees of the Honey Rock Camp realize the incredible resource the lake provides the camp in terms of educational and recreational opportunity.

TLWA members should ensure that a representative from the Honey Rock Camp included within future Planning Committees. Additionally, a Honey Rock representative should attend each TLWA annual meeting so that an open relationship is fostered and each group is clear on activities surrounding the management and use of the lake. More information on this particular management entity can be found in Management Goal 6.

<u>State of Wisconsin</u> The WDNR is responsible for managing the natural resources of the State of Wisconsin. Primary interaction with the WDNR is from an advisory and regulatory perspective. The TLWA has worked closely with the

Regional Lakes Coordinator (Kevin Gauthier – 715.365.8937) and that relationship should continue. Long Lake contains a highly valued fishery. The TLWA should be in contact with the WDNR fisheries biologist (John Kubisiak – 715.365.8919) at least once a year to discuss fish stocking plans and other pertinent fisheries-related issues. As discussed within the Fisheries Section, Long Lake falls within the ceded territory based on the Treaty of 1842 (Figure 3.4-1). This treaty grants specific off-reservation rights to the Native American community including a regulated spear fishery. The WDNR fisheries biologists are involved with this process and a direct link to GLIFWC biologists is not necessary.

<u>County and County-wide Associations</u> While all of Long Lake is within Oneida County, part of the Eagle River channel upstream of the Burnt Rollways Dam is in Vilas County. Lake conservation specialist at the OCLWCD (Nancy Hollands – 715.369.7835) is available to discuss specific conservation projects applicable to Long Lake. While it is important to foster a direct relationship with these entities, having SGLA representatives participating in county-wide associations such as the OCLRA is the best way to ensure the association gains from this pooled knowledge base of lake management and awareness. These representatives would attend all meetings and in their absence, an alternate would take their spot.

<u>Unified Lower Eagle River Chain of Lakes Commission</u> The ULERCLC is the united group representing the nine lakes downstream of the Burnt Rollways Dam. Because the TLWA and ULERCLC are essentially neighbors and utilizing parts of the same large chain of lakes, an understanding of the management practices and other activities happening on the Eagle River chain is of great importance to the TLWA. The TLWA should elect a volunteer that would keep track of the minutes generated from ULERCLC meetings, and report any items that would be of interest to the TLWA at the TLWA board meetings.

Action Steps:

Please see description above.

Management Goal 4: Maintain Current Water Quality Conditions

Management Action: Monitor water quality through WDNR Citizens Lake Monitoring Network.

Timeframe: Continuation and expansion of current effort.

Facilitator: Planning Committee.

Description: Monitoring water quality is an important aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to discovering the reason as to why the trend is developing.

The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. At this time, there are no Long Lake volunteers currently collecting data as a part of the CLMN. Volunteers trained by the WDNR as a part of the CLMN program begin by collecting Secchi disk transparency data for at least one year, then if the WDNR has availability in the program, the volunteer may enter into the *advanced program* and collect water chemistry data including chlorophyll-a, and total phosphorus. The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. Note: as a part of this program, these data are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS).

At a minimum, CLMN volunteers collecting Secchi disk data should be in place on Long Lake. Currently, the advanced CLMN program is not accepting additional lakes to participate in the program. However, it is important to get volunteers on board with the base Secchi disk data CLMN program so that when additional spots open in the advanced monitoring program, volunteers from Long Lake will be ready to make the transition into more advanced monitoring.

It is the responsibility of the Planning Committee to coordinate new volunteers as needed. When a change in the collection volunteer occurs, it will be the responsibility of the Planning Committee to contact Sandra Wickman (715.365.8951) or the appropriate WDNR/UW Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:

Please see description above.

Management Action: Reduce phosphorus and sediment loads from shoreland watershed to Long Lake.

Timeframe: Begin 2011.

Facilitator: Education Committee.

Description: As the watershed section discusses, the Long Lake watershed is in good condition; however, watershed inputs still need to be focused upon, especially in terms of the lake's shoreland properties. These sources include faulty septic systems, shoreland areas that are maintained in an unnatural manner, impervious surfaces.

On April 14th, 2009, Governor Doyle signed the "Clean Lakes" bill (enacted as 2009 Wisconsin Act 9) which prohibits the use of lawn fertilizers containing phosphorus. Phosphorus containing fertilizers were identified as a major contributor to decreasing water quality conditions in lakes, fueling plant growth. This law went into effect in April 2010. While this law also bans the display and sale of phosphorus containing fertilizers, educating lake stakeholders about the regulations and their purpose is important to ensure compliance.

To reduce these negative impacts, the TLWA will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include newsletter articles and guest speakers at association meetings. The Association website is (and has been) a good venue for broadcasting awareness. A good initial educational topic may be a discussion of the Oneida County Private Onsite Wastewater Treatment System Ordinance, which requires septic tanks to be enrolled in the County's Maintenance Program no later than October 1st of 2013. Phase II of this initiative requires visual inspections, and, if necessary, pumping of septic tanks every 3 years.

Topics of educational items may include benefits of proper septic system maintenance, methods and benefits of shoreland restoration, including reduction in impervious surfaces, and the options available regarding conservation easements and land trusts.

Action Steps:

1. Recruit a member of the planning committee or other interested Long Lake property owner to be an advocate and facilitator for shoreline conservation and education.
2. Facilitator gathers appropriate information from WDNR, UW-Extension, Oneida County, and other sources.
3. Facilitator summarizes information for newsletter articles and recruits appropriate speakers for association meetings (development of conservation and restoration education model).
4. Facilitator takes results of Shoreland Condition Assessment (See next Management Action) and identifies feasible areas for conservation work. May visit with new home owners to discuss conservation efforts, or meet with candidates to discuss runoff mitigation possibilities.

Management Action: Complete Shoreland Condition Assessment as a part of next management plan update.

Timeframe: Begin 2011.

Facilitator: Board of Directors.

Description: As discussed above, unnatural and developed shorelands can negatively impact the health of a lake, both by decreasing water quality conditions as well as removing valuable habitat for fish and other animal species that reside in and around the lake. Understanding the shoreland conditions around Long Lake will serve as an educational tool for lake stakeholders as well as identify areas that would be suitable for restoration. Shoreland restorations would include both in-lake and shoreline habitat enhancements. In-lake enhancements would include the introduction of coarse woody debris in the littoral zone, a valuable fisheries habitat component around the shores of Long Lake. Shoreline enhancements would include leaving 35-foot no-mow zones to act as a buffer between residences and the lake or by planting native herbaceous, shrub, and tree species as appropriate for Vilas and Oneida Counties in this sensitive area. Ecologically high-value areas delineated during the survey would also be selected for protection, possibly through conservation easements or land trusts (www.northwoodslandtrust.org).

Projects that include shoreline condition assessment and restoration activities will be better qualified to receive state funding in the future. These activities could be completed as an amendment to this management plan and would be appropriate for funding through the WDNR small-scale Lake Planning Grant program. Beginning in 2010, the remaining lakes of the Three Lakes Chain will have a shoreland assessment completed as part of their management plans. It is possible to have Long Lakes' assessment completed in conjunction with a Management Plan update, to be completed in five years.

Action Steps: See description above.

Management Goal 5: Improve Fishery Resource and Fishing

Management Action: Work with fisheries managers to enhance the walleye fishery on Long Lake.

Timeframe: Ongoing.

Facilitator: Board of Directors.

Description: As stated within the Fisheries Section, Long Lake stakeholders and fisheries managers would like to see an increase in size of walleye – the Three Lakes Chain's primary predator and gamefish. From 1996 until 2009, walleye harvest was regulated under a protected slot system, in which fish from 14" to 18" could not be kept. Additionally, a daily bag limit of 3 walleye was in place, with only 1 fish over 18" allowed to be kept. Prior to 1996, there was no minimum length limit in effect. Based upon survey studies completed as recently as 2007, there has been no observed change in walleye sizes between the two time periods (before and after 1996).

WDNR biologists proposed a rule change, effective 2011, which would initiate a no minimum length limit on walleye with a 5 fish daily bag limit, however only one fish longer than 14" could be kept. This adjustment would allow the fishery, which experiences high recruitment but slow growth, to produce a higher fishable and spawning stock.

In order to keep informed of survey studies and stocking of Long Lake and the Three Lakes Chain, a TLWA representative should be selected to contact WDNR fisheries biologist John Kubisiak (715.365.8919) at least once a year for an update, which can be published on the association's website and in periodic newsletter.

Action Steps:

1. See description above.

Management Goal 6: Develop Plan to Integrate Honey Rock Camp Into Lake Management Activities and Protection

Management Action: Consult with Honey Rock leadership to build into their program the maintenance of a healthy long Lake ecosystem.

Timeframe: Ongoing.

Facilitator: Long Lake Planning Committee.

Description: Honey Rock owns a large amount of the eastern shoreline of Long Lake. During the summer months Honey Rock uses the lake heavily for both silent water sports and water skiing as well as swimming, etc. As discussed in Management Goal 2, the presence of the Honey Rock Camp on Long Lake has both positive and perceived negative aspects. Fortunately, to alleviate potential problems and to work together in Long Lake's best interest, the TLWA and Honey Rock administration have contacted one another to create strategy for future management and protection of the lake. The action steps below are the result of discussions between these two entities on how they may coexist and work toward protecting the Long Lake resource.

Action Steps:

1. Just as Honey Rock has maintenance programs for its facilities it must consider a maintenance program for the lake it uses.
2. Honey Rock will adopt its shoreline for identification of invasive species and participate in the adopt-a-shoreline program.
3. Honey Rock needs to use its best efforts to stay clear of weed beds while running its water ski programs.
4. Honey Rock will consider the effects on its neighbors of noise levels created by some of its programs.
5. The Long Lake Planning Committee will ensure that a Honey Rock representative will be present and actively involved in lake matters.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Long Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in the lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected with a 3-liter Van Dorn bottle at the subsurface (S) and near bottom (B). Sampling occurred once in spring, fall, and winter and three times during summer. Samples were kept cool and preserved with acid following standard protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included the following:

Parameter	Spring		June		July		August		Fall		Winter	
	S	B	S	B	S	B	S	B	S	B	S	B
Total Phosphorus	●	●	●	●	●	●	●	●	●	●	●	●
Dissolved Phosphorus	●	●			●	●					●	●
Chlorophyll a	●		●		●		●		●			
Total Kjeldahl Nitrogen	●	●			●	●					●	●
Nitrate-Nitrite Nitrogen	●	●			●	●					●	●
Ammonia Nitrogen	●	●			●	●					●	●
Laboratory Conductivity	●	●			●	●						
Laboratory pH	●	●			●	●						
Total Alkalinity	●	●			●	●						
Total Suspended Solids	●	●	●	●	●	●	●	●	●	●	●	●
Calcium	●											

In addition, during each sampling event Secchi disk transparency was recorded and a temperature, pH, conductivity, and dissolved oxygen profile was be completed using a Hydrolab DataSonde 5.

Watershed Analysis

The watershed analysis began with an accurate delineation of Long Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the Wisconsin initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Long Lake during a June 2009 field visit, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on the system to characterize the existing communities within each lake and included inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in "Appendix D" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin - Draft, (April, 2007) was used to complete the studies. Based upon advice from the WDNR, the following point spacing and resulting number of points comprised the surveys:

Lake	Point-intercept Resolution	Number of Points	Survey Dates
Long Lake	62 m	609	July 3, 2009
Eagle River channel	30 m	96	July 3, 2009

Community Mapping

During the species inventory work, the aquatic vegetation community types within Long Lake (emergent and floating-leaved vegetation) were mapped using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the point-intercept surveys and the community mapping surveys were recorded to provide a complete species list for the lake.

Treatment Monitoring

The methodology used to monitor the 2009 herbicide treatments is included within the results section under the heading: *Treatment Monitoring.*

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